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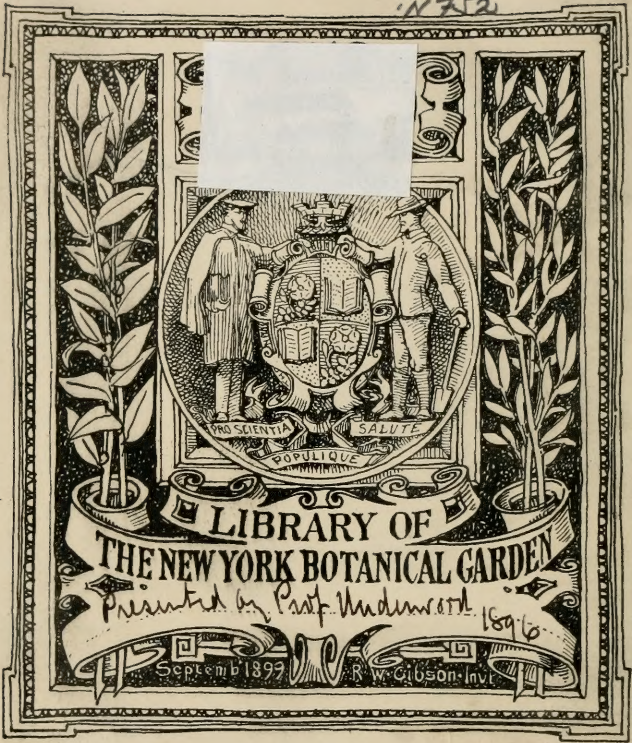

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EXPERIMENT STATION,
No. ....

EIGHTH ANNUAL REPORT

OF THE

Agricultural Experiment Station.

ITHACA, N. Y.

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IN ASSEMBLY,

APRIL 20, 1896.

EIGHTH ANNUAL REPORT

OF THE

AGRICULTURAL EXPERIMENT STATION OF CORNELL UNIVERSITY.

STATE OF NEW YORK:
DEPARTMENT OF AGRICULTURE,
ALBANY, *April* 20, 1896.

To the Honorable the Legislature of the State of New York:

In accordance with the provisions of the statutes relating thereto, I have the honor to herewith transmit the Report of the Agricultural Experiment Station at Cornell University.

FRED C. SCHRAUB,
Commissioner of Agriculture.

REPORT OF THE DIRECTOR.

To the President of Cornell University:

Sir.— I have the honor to transmit herewith my eighth annual report, with those of the treasurer, the chemist, the botanist and arboriculturist, the cryptogamic botanist and the plant pathologist, the entomologist, the agriculturist, the horticulturist and that of the assistant professor of dairy husbandry and animal industry; together with an appendix of 22 bulletins and a spray calendar, covering the year ending December 31, 1895. Also, a detailed statement of the receipts and expenditures for the fiscal year ending June 30, 1895.

The year has been unusually fruitful in valuable results. As the wants of the farmers become more clearly defined we are enabled to better and better meet their demands. An inspection of the publications of the year will show that the demand for original, accurate investigations directly related to both the practical and scientific sides of agriculture has been very fully met.

During recent years the ravages of the insect and fungous enemies of cultivated plants have become so numerous that many farmers have felt like abandoning the production of the tenderer and higher class of fruits and vegetables, the very kind of products which uniformly result, when successfully raised, in bringing the best returns to the producer.

During the year an effort has been made to change the practice of the orchardists with the happiest results. By the instruction given at the schools and by bulletins, the fruit growers have been taught that most of their failures have been due to partial soil exhaustion and to careless culture or to no culture. As a result of our efforts, numerous orchards, heretofore kept continuously in grass or grain, have received continuous, clean culture until the last of August with marked benefit. Where suitable fertilizers were applied in conjunction with clean and continuous culture, the fruit has been most abundant and of superior quality. The benefits which have accrued and are certain to accrue from our teaching and investigations during this year, are so great and far reaching that one hesitates to place a money value upon them, lest he be charged with exaggeration.

The numerous letters of appreciation which have been received and the great call for bulletins, justifies the belief that the work of the year has been of a very high character.

All the various divisions of the station are working so harmoniously and effectively that no changes are recommended. The office of the director has become to a large extent what I believe it was the desire it should become — a sort of clearing house. During the winter months a hundred written communications frequently reaches the office each day. The inquiries embrace a wide range of subjects, but the station staff, composed as it is of so many able specialists, is able to give help and valuable information in almost every instance. About one ton of mail matter during the summer and two tons during the winter have been sent out monthly. Our foreign exchange now amounts to 250 and is steadily increasing.

Experiments already completed have furnished valuable material for six or eight additional bulletins, which will be published in the near future.

The spray calendar published in 1894, was revised and a second edition was issued, the first one having become exhausted at an early date. The demand for them still continues and a third edition will be printed in the near future. The titles of the bulletins issued during the year are as follows:

January, No. 84.— The Recent Apple Failures.

February.— Spray Calendar.

March, No. 85.— Whey Butter.

March, No. 86.— The Spraying of Orchards.

April, No. 87.— The Dwarf Lima Bean.

April, No. 88.— Early Lamb Raising.

April, No. 89.— Feeding Pigs.

April, No. 90.— The China Aster.

April, No. 91.— Recent Chrysanthemums.

May, No. 92.— Feeding Fat to Cows.

May, No. 93.—The Cigar-Case-Bearer.

May, No. 94.— Damping Off.

June, No. 95.— Winter Muskmelons.

June, No. 96.— Forcing-house Miscellanies.

July, No. 97.— Entomogenous Fungi.

July, No. 98.— Cherries.

August, No. 99.— Blackberries.

September, No. 100.— Evaporated Raspberries in Western New York.

September, No. 101.— The Spraying of Trees, with Remarks on Canker worm.

October, No. 102.— Care of Fruit Trees, General Observations.

October, No. 103.— Soil Depletion in Respect to Care of Fruit Trees.

November, No. 104.— Climbing Cutworms in Western New York.

December, No. 105.—Tests of Cream Separators.

I. P. ROBERTS.

Report of the Treasurer.

The Cornell University Agricultural Experiment Station, in account with the United States appropriation, 1894-5:

Dr.

To receipts from treasurer of the United States, as per appropriation for fiscal year ending June 30, 1895, as per act of Congress approved March 2, 1887...	$13,500 00

Cr.

Salaries	$8,448 42
Labor	1,065 48
Publications	2,181 68
Postage and stationery	328 05
Freight and express	118 43
Heat, light and water	28 89
Chemical supplies	164 22
Seeds, plants and sundry supplies	317 78
Fertilizers	25 03
Feeding stuffs	192 62
Library	83 33
Tools, implements and machinery	27 75
Furniture and fixtures	102 25
Scientific apparatus	27 73
Live stock	6 00

Traveling expenses	$39 79
Contingent expenses	10 00
Building and repairs	332 55
	$13,500 00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Cornell University Agricultural Experiment Station for the fiscal year ending June 30, 1895; that we have found the same well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been $13,500.00, and the corresponding disbursements, $13,500, for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance on hand.

And we further certify that the expenditures have been solely for the purpose set forth in the act of Congress approved March 2, 1887.

(Signed.) H. B. LORD,
[L. S.] GEO. R. WILLIAMS,
Auditors.

Attest:
EMMONS L. WILLIAMS,
Custodian.

Report of the Chemist.

To the Director of the Cornell University Agricultural Experiment Station:

SIR.— I have to report that the work of the Chemical Division of the Experiment Station has been carried on in the usual manner during the year 1895.

Ninety-five substances have been sent to the laboratory for analysis, requiring 200 determinations in duplicate. The results of this work are given in various bulletins of the station. The largest part of the analyses were made by Mr. G. W. Cavanaugh; the rest were made under his immediate direction.

G. C. CALDWELL.

Report of the Botanist.

To the Director of the Cornell University Agricultural Experiment Station:

Sir.—The important work of this department consists, as heretofore, of studies, investigations and experiments concerning the diseases of plants. This work is wholly in charge of the Associate Professor of Cryptogamic Botany, George F. Atkinson, whose report is herewith inclosed.

In Phanerogamic Botany no work has been undertaken beyond the answering of inquiries, the naming of weeds and other plants, and the carrying on of a considerable correspondence relating to other subjects.

A. N. PRENTISS.

Report of the Cryptogamic Botanist.

To the Director of the Cornell University Agricultural Experiment Station:

SIR.— I respectfully submit the following report for the past year:

One bulletin (Bulletin 94, May, 1895), has been published during the year, which treats of several of the obscure fungi which cause the rot of seedlings and other green-house plants. The bulletin consists of forty pages and is illustrated with six full-page plates, representing the life history and development of the parasites.

Other investigations are in progress which, in time, will be presented for publication, especially on the leaf spot of the quince and pear. In connection with this, there has been discovered a hitherto unknown fungus which is quite abundant on pear leaves, causing much the same appearance and injury as the ordinary leaf spot (Entomosporium maculatum), and probably many times having been mistaken for it, since it is impossible from the usual popular descriptions of this fungus to distinguish it from this new one. Probably many of the descriptions which have been given heretofore of experiments for the prevention of leaf-spot have been wrongly applied to the Entomosporium. Several other investigations which were mentioned in the last report are still under way.

Dr. E. J. Durand, assistant cryptogamic botanist, has been engaged upon the investigations of the life history and development of two important parasitic fungi. One, causing a disease of currant canes, has, for several years, been reported in different sections of the state, and indeed from other states, but up to this time the cause and the development of the organism has been unknown. Dr. Durand has succeeded in following out and determining the complete life history of the parasite, and will soon have the matter ready for publication as a bulletin.

The development of a fungus parasite of stone fruits, Cladosporium carpophilum, is also being carefully investigated by Dr. Durand, and the matter is in a fair way for completion.

Besides these investigations there has been much work of a routine kind, in the way of determining specimens of fungi that have come to our hands for this purpose.

Some extensive experiments have also been carried on in determining the number of bacteria in milk at different stages in the pasteurization of the same; and we have now in progress studies of some peculiar organisms which give an uneven and undesirable coloring to cheese during its curing. The trouble exists in several of the cheese factories of the state.

The needs of the division are so great that I hesitate to enumerate even any of them. It is desirable that an assistant should be able to give his entire time to the investigation of the numerous problems that are arising in connection with the diseases of plants, and that the division should be otherwise relieved by an instructor who could give his entire time to the instruction in the laboratory and the care of the Cryptogamic Herbarium. There are many important problems which can not be even entered upon without continued assistance and the opportunities which would come from the appropriation of a larger fund to the division. All of the work is of such a character that it requires expensive apparatus for carrying it on, and needs the accumulation of type material which can be used in the comparison of the material which is being investigated.

Among other things, one of the most pressing needs is a small but properly appointed culture house or forcing house, near to the laboratory, where plants for experimentation upon the different diseases could be under close observation, and could be used for studying more carefully the relation of the parasites to the host, and of the effect of surrounding conditions.

Even for the continuance of the work as it is now carried on more funds are necessary than have been appropriated this year.

These suggestions are respectfully offered for your consideration.

GEORGE F. ATKINSON.

Report of the Entomologist.

To the Director of the Cornell University Agricultural Experiment Station:

Sir.— During the past year several injurious insects have been investigated by this division of the station. For instance, we have demonstrated that the mysterious "dying back or blighting" of the tender tips of peach nursery stock is largely, if not entirely due to the punctures of the common and well-known tarnished plant bug. A maggot, which burrows down the center of and finally girdles young raspberry shoots, was also quite destructive in several localities; we have full, illustrated notes on its habits and life history, but have as yet failed to get the adult insect — an Anthomyiid fly. Some of the scale insects which are common here in the east have been bred on trees growing in the insectary, with the result that new and very important facts regarding their life histories have been learned.

The 500 peach trees in our extensive peach-borer experiment were first treated in 1894, and the examination last spring revealed several interesting and important facts. Although the careful examination and treatment of each one of these trees involves much labor, the results thus far obtained afford sufficient encouragement to warrant the continuance of the experiment for a series of years.

Considerable work was undertaken by this division during 1894 and 1895, under the auspices of the so-called Experiment

Station Extension or Nixon bill. The results of these investigations are embodied in the following bulletins, issued during the past year:

93. The Cigar-Case-Bearer in Western New York.
104. Climbing Cutworms in Western New York.

A large share of our time has been occupied with the correspondence of the division. We have always taken great pains to give every correspondent the latest and best information, for we believe this is one of the most important phases of our work. The correspondence has nearly doubled during the past year. Six hundred and fifty letters of inquiry regarding insects and their injuries were answered; one hundred twenty of these answers were prepared for publication and have appeared in the columns of agricultural journals.

Respectfully submitted,

M. V. SLINGERLAND,

Assistant Entomologist.

Report of the Agriculturist.

To the Director of the Cornell University Agricultural Experiment Station:

SIR.— The work of the agricultural division during the greater part of the year has been under the direction of Mr. G. C. Watson, who resigned his position in August to accept the chair of agriculture at the Pennsylvania State College.

During the year the investigations with reference to the value of feed stuffs have been continued and at the present time we are feeding a lot of twenty-five pigs to determine the value of different rations. The important line of work which was commenced several years ago with barn manures has been continued and valuable and interesting results obtained. Experiments to determine the relation between cultivation and conservation of soil moisture have been conducted on the permanent plots. It is expected that the experiments with field crops and fertilizers will be continued through a series of years, for in this way only can results of any value be obtained.

L. A. CLINTON.

Report of the Horticulturist.

To the Director of the Cornell University Agricultural Experiment Station:

Sir.— The work of the horticultural division during the year 1895 has been chiefly concerned with the investigation and teaching requested of the station by the so-called Experiment Station Extension or Nixon bill. The investigational work under the auspices of this statute has been of two general types — that made at the home station, and that which was undertaken in the fruit plantations of the western part of the State. Of the former type, we have published results in bulletins as follows, during the year:

87. The Dwarf Lima Beans.
90. The China Asters; with Remarks upon Flower Beds.
91. Chrysanthemums.
95. Winter Muskmelons.
96. Forcing-house Miscellanies.

The work of the latter class — that done partly or chiefly on the plantations of farmers — has given more profuse results in publication. I have been fortunate to have secured the co-operation of my colleagues in this work, and part of the bulletins which have appeared in fulfillment of the law have been written by persons outside my division. Those bulletins which were prepared by writers under the direct supervision of the horticultural division are as follows:

84. The Recent Apple Failures of Western New York.
86. The Spraying of Orchards — Apples, Quinces, Plums.
98. Cherries.
99. Blackberries.
100. Evaporated Raspberries in Western New York.
101. Notions about the Spraying of Trees; with Remarks on the Canker Worm.
102. General Observations Respecting the Care of Fruit Trees; with some Reflections upon Weeds.

A full and explicit account of the work which has been attempted under this State grant is given in Bulletin 110.

The accustomed work at the home station has taken a secondary place to this State work during the past two years. We have also suffered a serious loss during the past season in the wanton destruction of all our cherry orchard, our entire vineyard, nearly our entire collection of native plums, and a large lot of seedling currants and other plants, by the grading which was done to provide for a site for the State Veterinary College. These plantations were devastated without warning, and the work of several years was irrevocably lost. The Experiment Station houses are getting old and are much in need of repairs. Our area is now so small that we can not expect to plan much new experimenting therein in fruit-culture; and it is now so completely occupied by permanent planting that experiments in vegetable gardening must henceforth be very limited and must eventually cease.

Respectfully submitted,

L. H. BAILEY.

Report of the Assistant Professor of Dairy Husbandry and Animal Industry.

To the Director of the Cornell University Agricultural Experiment Station:

SIR.—The work of the Agricultural Experiment Station in the dairy division has been mainly continued along the same lines as for several years past. During the year three bulletins have been published:

85. Whey Butter.
92. Feeding Fat to Cows.
105. Tests of Cream Separators.

The records of our herd of dairy cows have been kept up during the year and are now continuous for something over four years. It is hoped to shortly publish a bulletin giving some of the results obtained.

We have also secured considerable data bearing upon the relation of milk production to food consumed in cases where animals have been forced for great production. Experiments are also under way concerning the relation of food to quality of milk and during the year some investigations have been made upon the subject of milk pasteurization and sterilization.

The efficiency of this division could be very materially increased if it were possible to secure the services of a trained bacteriologist and chemist.

Very respectfully submitted,

H. H. WING.

APPENDIX II.

DETAILED STATEMENT

OF THE

Receipts and Expenditures of the Cornell University Agricultural Experiment Station, for the Fiscal Year Ending June 30, 1895.

RECEIPTS.

From Horticultural Division.

1894.			
Oct.	17.	Sundry fruits	$27 00
	23.	Sundry fruits	2 56
Dec.	6.	Sundry fruits	25 00
	17.	Sundry fruits	9 00
1895.			
Feb.	1.	Hauling coal	6 30
	28.	Products sold (sundry fruits)	18 00
			$87 86

From Office.

1895.			
May	8.	One hundred spray calendars	$1 00

EXPENDITURES.

For Salaries.

1894.			
July	31.	I. P. Roberts, director, one month	$125 00
		H. H. Wing, dairyman, one month	104 16
		L. H. Bailey, horticulturist, one month	125 00
		G. F. Atkinson, cryptogamic botanist, one month	91 66
		G. C. Watson, assistant agriculturist, one month	100 00
		M. V. Slingerland, assistant entomologist, one month	100 00
		G. W. Cavanaugh, assistant chemist, one month	66 66
Aug.	31.	I. P. Roberts, director, one month	125 00
		H. H. Wing, dairyman, one month	104 16
		L. H. Bailey, horticulturist, one month	125 00
		G. F. Atkinson, cryptogamic botanist, one month	91 66
		G. C. Watson, assistant agriculturist, one month	100 00
		M. V. Slingerland, assistant entomologist, one month	100 00
		G. W. Cavanaugh, assistant chemist, one month	66 66
		H. W. Smith, clerk, 23-26 month	55 28
Sept.	30.	I. P. Roberts, director, one month	125 00
		H. H. Wing, dairyman, one month	104 16
		L. H. Bailey, horticulturist, one month	125 00

1894.

Sept.	30.	G. F. Atkinson, cryptogamic botanist, one month	$91 66
		G. C. Watson, assistant agriculturist, one month	100 00
		M. V. Slingerland, assistant entomologist, one month	100 00
		G. W. Cavanaugh, assistant chemist, one month	66 66
		H. W. Smith, clerk, one month	62 50
Oct.	31.	I. P. Roberts, director, one month,	125 00
		H. H. Wing, dairyman, one month	104 16
		L. H. Bailey, horticulturist, one month	125 00
		G. F. Atkinson, cryptogamic botanist, one month	91 66
		G. C. Watson, assistant agriculturist, one month	100 00
		M. V. Slingerland, assistant entomologist, one month	100 00
		G. W. Cavanaugh, assistant chemist, one month	66 66
		H. W. Smith, clerk, one month	62 50
Nov.	30.	I. P. Roberts, director, one month	125 00
		H. H. Wing, dairyman, one month	104 16
		L. H. Bailey, horticulturist, one month	125 00
		G. F. Atkinson, cryptogamic botanist, one month	91 66
		G. C. Watson, assistant agriculturist, one month	100 00

1894.			
Nov.	30.	M. V. Slingerland, assistant entomologist, one month	$100 00
		G. W. Cavanaugh, assistant chemist, one month	66 66
		H. W. Smith, clerk, one month	62 50
Dec.	31.	I. P. Roberts, director, one month	125 00
		H. H. Wing, dairyman, one month	104 16
		L. H. Bailey, horticulturist, one month	125 00
		G. F. Atkinson, cryptogamic botanist, one month	91 66
		G. C. Watson, assistant agriculturist, one month	100 00
		M. V. Slingerland, assistant entomologist, one month	100 00
		G. W. Cavanaugh, assistant chemist, one month	66 66
		H. W. Smith, clerk, one month	62 50
1895.			
Jan.	31.	I. P. Roberts, director, one month	125 00
		H. H. Wing, dairyman, one month	104 16
		L. H. Bailey, horticulturist, one month	125 00
		G. F. Atkinson, cryptogamic botanist, one month	91 66
		G. C. Watson, assistant agriculturist, one month	100 00
		M. V. Slingerland, assistant entomologist, one month	100 00
		G. W. Cavanaugh, assistant chemist, one month	66 66

1895.			
Feb.	28.	I. P. Roberts, director, one month	$125 00
		H. H. Wing, dairyman, one month	104 16
		L. H. Bailey, horticulturist, one month	125 00
		G. F. Atkinson, cryptogamic botanist, one month	91 66
		G. C. Watson, assistant agriculturist, one month	100 00
		M. V. Slingerland, assistant entomologist, one month	100 00
		G. W. Cavanaugh, assistant chemist, one month	66 66
		H. W. Smith, clerk, one month	62 50
March	30.	I. P. Roberts, director, one month	125 00
		H. H. Wing, dairyman, one month	104 16
		L. H. Bailey, horticulturist, one month	125 00
		G. F. Atkinson, cryptogamic botanist, one month	91 66
		G. C. Watson, assistant agriculturist, one month	100 00
		G. W. Cavanaugh, assistant chemist, one month	66 66
April	30.	I. P. Roberts, director, one month	125 00
		H. H. Wing, dairyman, one month	104 16
		G. F. Atkinson, cryptogamic botanist, one month	91 66
		G. C. Watson, assistant agriculturist, one month	100 00
		G. W. Cavanaugh, assistant chemist, one month	66 66

1895.			
April	30.	H. W. Smith, clerk, one month	$62 50
May	31.	I. P. Roberts, director, one month	125 00
		H. H. Wing, dairyman, one month	104 16
		G. F. Atkinson, cryptomagic botanist, one month	91 66
		G. C. Watson, assistant agriculturist, one month	100 00
		G. W. Cavanaugh, assistant chemist, one month	66 66
June	30.	I. P. Roberts, director, one month	125 00
		H. H. Wing, dairyman, one month	104 16
		G. F. Atkinson, cryptomagic botanist, one month	91 66
		G. C. Watson, assistant agriculturist, one month	100 00
		G. W. Cavanaugh, assistant chemist, one month	66 66
		Total for salaries	$8,205 04

For Building.

1894.			
Oct.	1.	Chimney for green-house	$230 00
1895.			
June	21.	Paint for insectary	7 65
	29.	Labor, painting insectary	30 00
		Total for buildings	$267 65

For Printing.

1894.			
July	21.	United States Express Co., expressage....	$0 30
	30.	United States Express Co., expressage....	25
	25.	J. Horace McFarland, electro............	35
	28.	N. Y. Engraving and Printing Co., cuts.....	3 78
Aug.	1.	United States Express Co., expressage....	55
	4.	United States Express Co., expressage.....	30
	7.	United States Express Co., expressage....	40
	10.	United States Express Co., expressage.....	25
	8.	United States Express Co., expressage.. ..	30
		United States Express Co., expressage.. ..	30
	15.	United States Express Co., expressage.....	30
	16.	John Allen, pen and ink drawing.........	4 54
	20.	National Express Co., expressage.........	75
	10.	National Express Co., expressage.........	45
	25.	National Express Co., expressage.........	75
Sept.	1.	E. G. Hance, cartage...................	1 00
Aug.	29.	L. V. R. R. Co., freight..................	2 90
	7.	N. Y. and Penn. Telegraph and Telephone Co., message.........................	40
	25.	W. F. Humphrey, 10,000 copies bulletin, No. 68..............................	180 25
Sept.	14.	National Express Co., expressage.......	1 00
	21.	E. G. Hance, cartage....................	75
	15.	L. V. R. R. Co., freight..................	3 80
	21.	National Express Co., expressage........	65
	13.	U. S. Express Co., expressage...........	25
	13.	U. S. Express Co., expressage...........	35
	27.	L. V. R. R. Co., freight..................	4 23

1894.			
Sept.	12.	Franklin Engraving Co., cuts	$66 50
Oct.	1.	Franklin Engraving Co., cuts	22 98
	3.	National Express Co., expressage	70
	8.	U. S. Express Co., expressage	30
	8.	Franklin Engraving Co., cut	80
	11.	Lovejoy Co., electro	17
	13.	L. V. R. R. Co., freight	4 65
	17.	National Express Co., expressage	75
	22.	E. G. Hance, cartage	1 00
	30.	E. G. Hance, cartage	75
	27.	U. S. Express Co., expressage	25
	31.	U. S. Express Co., expressage	25
	29.	Lovejoy Co., electros	1 44
Nov.	1.	Western Union Telegraph Co., message	27
	21.	U. S. Express Co., expressage	25
	24.	U. S. Express Co., expressage	25
	16.	U. S. Express Co., expressage	25
	29.	W. F. Humphrey, 10,100 copies Bulletin No. 73	338 50
	24.	Franklin Engraving Co., cuts	13 13
	25.	U. S. Express Co., expressage	25
	28.	U. S. Express Co., expressage	40
Dec.	5.	National Express Co., expressage	25
	3.	Franklin Engraving Co., half-tone cut	2 50
	21.	U. S. Express Co. expressage	30
	24.	U. S. Express Co., expressage	30
	24.	Lovejoy Co., electros	73
	27.	Lovejoy Co., electros	4 79

1895.

Jan.	24.	U. S. Express Co., expressage	$0 25
	29.	L. V. R. R. Co., freight	12 00
	31.	E. G. Hance, cartage	1 50
Feb.	5.	U. S. Express Co., expressage	25
	13.	U. S. Express Co., expressage	25
	16.	U. S. Express Co., expressage	25
	16.	U. S. Express Co., expressage	25
Jan.	26.	W. F. Humphrey, 12,000 copies Bulletin, No. 78	640 40
Feb.	21.	U. S. Express Co., expressage	25
	2.	Matthews-Northrup Co., cuts	5 00
	25.	L. V. R. R. Co., freight	2 19
	26.	U. S. Express Co., expressage	25
	28.	E. G. Hance, cartage	50
	22.	W. F. Humphrey, 11,000 copies Bulletin, No. 82	110 00
	8.	W. F. Humphrey, 12,000 spray calendars	40 50
March	9.	National Express Co., expressage	25
	7.	Franklin Engraving Co., zinc cut	75
	19.	L. V. R. R. Co., freight	1 22
	18.	W. F. Humphrey, 12,000 copies Bulletin, No. 85	48 80
	12.	U. S. Express Co., expressage	15
	20.	U. S. Express Co., expressage	30
	23.	E. G. Hance, cartage	50
	28.	National Express Co., expressage	65
	26.	Franklin Engraving Co., half-tone cuts	20 75
April	8.	O. D. Watson, pen drawing	1 50
	10.	U. S. Express Co., expressage	25

1895.

April	18.	U. S. Express Co., expressage	$0 25
	29.	National Express Co., expressage	65
	30.	L. V. R. R. Co., freight	3 27
	24.	U. S. Express Co., expressage	25
May	3.	U. S. Express Co., expressage	25
	6.	L. V. R. R. Co., freight	1 30
	4.	W. F. Humphrey, 12,000 copies Bulletin, No. 89.	73 90
April	27.	W. F. Humphrey, 12,000 copies Bulletin, No. 88.	146 20
May	8.	E. G. Hance, cartage	1 00
	13.	U. S. Express Co., expressage	25
	15.	W. F. Humphrey, 12,000 copies Bulletin, No. 92.	97 00
	30.	U. S. Express Co., expressage	25
	18.	L. V. R. R. Co., freight	5 10
	27.	L. V. R. R. Co., freight	1 50
	29.	L. V. R. R. Co., freight	3 59
June	8.	U. S. Express Co., expressage	25
	15.	U. S. P. O. Stamps	12 00
	15.	E. G. Hance, cartage	1 75
	21.	U. S. Express Co., expressage	25
	19.	Lovejoy Co., electros	1.16
		Total for printing	$1,910 99

For Office Expenses.

1894.

July	3.	U. S. P. O., stamps	$15 00
	3.	E. G. Hance, cartage	1 00

1894.		
July	1. Treman, King & Co., index tins	$0 60
	5. Andrus & Church, stationery	5 35
	21. U. S. Express Co., expressage	30
Aug.	7. U. S. P. O. stamps and postal cards	6 00
	8. National Express Co., expressage	45
	6. H. H. Ballard, clips	10 10
	10. Andrus & Church, pencils	40
	11. Letter copy book, Andrus & Church	1 25
	11. E. Hance, cartage	1 00
	14. National Express Co., expressage	30
	11. George P. Rowell & Co., American Newspaper Directory	5 00
	31. U. S. P. O. stamps	10 00
Sept.	3. F. P. Hatch, labor	11 70
Aug.	18. Andrus & Church, printing and stationery	6 04
Sept.	20. Andrus & Church, envelopes	4 95
	19. Andrus & Church, supplies	1 30
Aug.	31. Nellie G. Works, labor	7 88
	31. Lizzie V. Maloney, labor	17 50
	31. Arthur Stout, labor	1 85
	31. Walter Tailby, labor	2 00
Sept.	22. Stationery and supplies, Andrus & Church	3 05
	26. Elgin Dairy report, stationery	2 50
	29. Andrus & Church, stationery	3 50
Oct.	4. Andrus & Church, stationery	5 16
	5. Ithaca Gaslight Co., gas	20
	6. Andrus & Church, pencils	1 00
	10. U. S. Express Co., expressage	40
	16. U. S. Express Co., expressage	40

1894.				
Oct.	17.	C. U. repairs, pigeon holes and office desk..	$11	87
	27.	W. O. Wyckoff, typewriter ribbons.......	2	00
	23.	Andrus & Church, printing..............		75
Nov.	1.	W. W. Root, labor.....................	6	75
	6.	Andrus & Church, Shannon binders.......	2	25
	3.	Andrus & Church, stationery............	3	75
	8.	U. S. Express, expressage..............		25
	1.	Ithaca Gas Light Co., gas..............		20
Sept.	4.	Platt & Colt, rubber stamp and brush....	4	90
Nov.	13.	E. D. Norton, ink......................		50
	16.	Andrus & Church, letter copy book.......	2	00
	30.	Lizzie V. Maloney, labor...............	32	50
	14.	H. H. Wing, traveling expenses.........	28	25
Dec.	6.	Ithaca Gas Light Co., gas..............		40
	11.	W. O. Wyckoff, mimeograph supplies.....	2	80
	15.	U. S. P. O., 3,000 stamped envelopes.......	66	00
	29.	Lizzie V. Maloney, labor...............	32	50
	22.	E. S. Tichenor & Son, chest of drawers....	12	50
1895.				
Jan.	7.	Andrus & Church, paper.................	1	75
	11.	W. O. Wyckoff, stationery..............	1	60
	5.	Ithaca Gas Light Co., gas..............		40
	14.	Andrus & Church, stationery............	3	50
	21.	Andrus & Church, printed letter heads....	4	75
	21.	Andrus & Church, stationery............		85
	26.	Andrus & Church, ink..................		75
Feb.	6.	Ithaca Gas Light Co., gas..............		40
	7.	Andrus & Church, stationery............	2	75
	5.	W. O. Wyckoff, typewriter ribbons........	2	00

1895.

Feb.	16.	Andrus & Church, stationery	$2 30
	21.	W. O. Wyckoff, mimeograph paper	1 75
	25.	W. O. Wyckoff, mimeograph ink	60
	28.	Nellie G. Works, labor	36 00
	28.	Arthur T. Stout, labor	12 80
	27.	Andrus & Church, printed cards	4 75
March	1.	Andrus & Church, letter copy book	2 50
	6.	Andrus & Church, stationery	1 10
	4.	U. S. Express Co., expressage	25
	5.	U. S. Express Co., expressage	25
	8.	U. S. Express Co., expressage	25
	12.	U. S. P. O. stamps	10 00
	14.	U. S. P. O., 500 stamped envelopes	10 80
	14.	A. A. A. C. & Exp. Sta., membership fee	10 00
	20.	W. O. Wyckoff, mimeograph supplies	2 20
	15.	Andrus & Church, printed slips	1 75
	15.	Andrus & Church, printed stationery	12 50
	30.	Arthur T. Stout, labor	5 72
	30.	G. Walter Tailby, labor	6 09
March	29.	Andrus & Church, printed letter heads	4 13
	27.	Andrus & Church, stationery	2 63
April	1.	W. O. Wyckoff, mineograph ink	60
	4.	Andrus & Church, stationery	88
	6.	Comstock Pub. Co., Comstock's Manual	3 75
	13.	George T. Lasher, U. S. Postal Guide	2 00
	20.	Nellie G. Works, labor	27 00
	26.	Andrus & Church, binding postal guide	90
	24.	Andrus & Church, desk trays	1 42
	30.	Lizzie V. Maloney, labor	12 00

1895.			
April	23.	W. O. Wyckoff, mineograph supplies.....	$1 95
	30.	Andrus & Church, lead pencils............	80
May	7.	U. S. Express Co., expressage............	25
	7.	U. S. Express Co., expressage.............	85
	31.	Lizzie V. Maloney, labor.................	40 50
	31.	E. G. Hance, cartage.....................	1 00
	31.	Arthur T. Stout, labor...................	10 00
	27.	Ithaca Rubber Stamp Co., repairing stamps	25
	14.	W. O. Wyckoff, mimeograph paper.......	1 75
June	1.	Andrus & Church, towels and brushes....	1 08
	18.	Andrus & Church, wrapping paper........	5 40
	21.	W. O. Wyckoff, typewriter ribbon.........	1 00
	29.	Lizzie V. Maloney, labor.................	37 50
	29.	H. G. Norwood, labor.....................	11 37
		Total for office expenses.............	$645 72

For Agricultural Division.

1894.			
July	10.	National Express Co., expressage........	$0 35
	9.	J. M. Thorburn & Co., clover seed.........	65
	11.	National Express Co., expressage........	25
	31.	National Express Co., expressage.........	75
Aug.	1.	U. S. Express Co., expressage............	3 30
	8.	Charles Payne, rabbits....................	6 00
	31.	Ithaca Calendar Clock Co., dynamometer apparatus............................	11 60
Sept.	1.	C. U. Agr. Dept., labor....................	6 65
	5.	U. S. Express Co., expressage............	50
	12.	Andrus & Church, stationery.............	4 83

1894.

Sept.	15.	Andrus & Church, stationery	$0 55
	29.	National Express Co., expressage	65
Oct.	3.	U. S. P. O., 500 stamped envelopes	10 90
	3.	National Express Co., expressage	30
	2.	E. & H. T. Anthony, photograph supplies	4 68
Sept.	20.	L. S. Wortman, tallow	3 00
	12.	Perry Seed Store, clover seed	1 60
Oct.	13.	National Express Co., expressage	65
	18.	L. V. R. R. Co., freight	80
	20.	Smiths & Powell, trees	9 40
	26.	National Express Co., expressage	80
	27.	National Express Co., expressage	65
Nov.	1.	National Express Co., expressage	40
Oct.	30.	Treman, King & Co., hardware	6 85
Nov.	2.	National Express Co., expressage	65
	2.	I. P. Roberts, traveling expenses	3 54
	5.	National Express Co., expressage	50
Oct.	24.	L. S. Wortman, tallow	23 88
	5.	J. S. Woodward & Son, drinking basins	8 40
Nov.	7.	U. S. Express Co., expressage	30
	8.	U. S. Express Co., expressage	35
	8.	U. S. Express Co., expressage	50
	9.	National Express Co., expressage	40
	10.	National Express Co., expressage	25
	9.	U. S. Express Co., expressage	30
	8.	Charles Wanzer, traveling expenses	4 00
	10.	National Express Co., expressage	65
Sept.	25.	C. J. Rumsey & Co., battery jars	4 20
Nov.	12.	National Express Co., expressage	65

1894.			
Nov.	10.	National Express Co., expressage	$0 30
	15.	National Express Co., expressage	60
	19.	National Express Co., expressage	35
	19.	National Express Co., expressage	30
	21.	National Express Co., expressage	1 00
	30.	Theodore Van Natta, labor	37 00
	30.	F. P. Hatch, labor	40 35
	30.	Henry J. Brown, labor	9 75
	30.	U. S. Express Co., expressage	30
Dec.	4.	National Express Co., expressage	50
	4.	National Express Co., expressage	35
Nov.	27.	L. S. Wortman, tallow	37 86
June	9.	E. McGillivray, photo plates	3 60
Dec.	22.	J. M. Trueman, labor	16 00
	15.	L. S. Wortman, tallow	18 66
Oct.	9.	Joe Fowles, cement	5 35
1895.			
Jan.	30.	National Express Co., expressage	70
Feb.	28.	Theodore Van Natta, labor	34 15
	28.	Joseph A. Kreuzer, labor	8 69
	1.	E. McGillivray, photo plates	3 21
March	15.	National Express Co., expressage	35
	20.	J. M. Trueman, labor	5 20
	23.	Andrus & Church, printed slips	4 75
April	16.	National Express Co., expressage	1 75
March	16.	A. Blanc & Co., sacaline, roots and seeds	1 15
Jan.	28.	Treman, King & Co., hardware	1 55
April	9.	J. M. Trueman, labor	14 00
	25.	National Express Co., expressage	25

1895.			
April	25.	A. D. Pratt, oats	$1 35
	26.	National Express Co., expressage	75
	23.	G. Cramer, photo plates	6 58
	20.	A. W. Livingston Sons, seed corn	52
	24.	D. Landreth & Sons, sunflower seeds	17
	29.	National Express Co., expressage	45
	30.	E. R. Ewell, labor	37 00
May	3.	National Express Co., expressage	30
	3.	Hook Bros., seed potatoes	1 80
	1.	C. E. Chapman, seed potatoes	80
April	27.	A. W. Horton, seed corn	1 00
Jan.	23.	Edward G. Allen, English periodicals	8 80
May	9.	E. C. & N. R. R. Co., freight	1 99
	13.	D., L. & W. R. R. Co., freight	58
	7.	L. V. R. R. Co., freight	50
April	16.	E. McGillivray, photo supplies	3 38
May	22.	A. W. Livingston Sons, seed corn	56
	2.	H. J. Baker & Bro., fertilizer	25 03
	31.	E. R. Ewell, labor	38 42
	31.	J. W. Gilmore, labor	2 10
June	10.	White & Burdick, chemicals	45
	28.	Neptune Meter Co., planimeter	5 00
	29.	H. G. Norwood, labor	15 54
	26.	Treman, King & Co., hardware	6 15
	29.	George Small, lumber	34 00
Jan.	3.	National Express Co., expressage	70
		Total for agricultural division	$566 62

For Horticultural Division.

1894.			
June	29.	E. G. Lodeman, expenses spraying orchards,	$11 95
July	2.	E. G. Lodeman, expenses spraying fruits. .	10 75
	3.	Driscoll Bros., lime and cement..........	14 50
	3.	Rothschild Bros., towels	2 00
	3.	Barr Bros., hardware	2 60
June	1.	White & Burdick, chemicals............	7 43
Feb.	2.	Fall Creek Milling Co., feed.............	9 77
March	2.	Fall Creek Milling Co., feed.............	10 25
	31.	Fall Creek Milling Co., feed..............	10 70
July	7.	J. S. McGowan, hay....................	23 28
	6.	Ithaca Gas-Light Co., gas................	38
	1.	Ira Grover, Jr., labor	41 00
	17.	G. H. Powell, money paid for labor........	18 00
	5.	Detroit Paper Package Co., berry baskets. .	4 00
	9.	Ernest Walker, Herbarium specimens.....	7 90
	28.	Ed. Nolan, labor	15 00
	28.	William Mann, labor	14 25
	31.	Ira Grover, Jr., labor	37 50
	30.	New York Engraving and Printing Co., cut,	8 23
Aug.	2.	C. T. Stephens, seeds..................	3 65
	14.	A. H. Perkins, maps..................	10 00
Sept.	3.	Ira Grover, Jr., labor	37 00
	8.	Henry A. Dreer, seeds...................	39
Aug.	25.	Henry A. Dreer, seeds..................	64
	27.	F. R. Pierson, rose plants...............	6 48
Oct.	1.	Ira Grover Jr., labor....................	37 50
May	17.	Andrus & Church, stationery............	50

1894.		
July	27. Driscoll Bros., bricks	$3 50
	7. Andrus & Church, printed cards	1 25
	20. Andrus & Church, printed labels	1 50
Aug.	3. Andrus & Church, printed labels	1 50
June	14. White & Burdick, chemicals	65
Sept.	11. John N. May, rose plants	3 00
Nov.	2. Ira Grover, Jr., labor	37 50
Aug.	9. J. F. More, agent, repairing harness	4 00
Oct.	30. White & Burdick, chemicals	1 25
Nov.	3. E. G. Lodeman, expenses spraying orchard,	12 75
Oct.	30. J. M. Thorburn & Co., plants	90
Nov.	14. J. M. Thorburn & Co., plants	43
Sept.	26. Burns Bros., shoeing horses	5 15
	29. Dennison Mfg. Co., shipping tags	70
Dec.	1. Ira Grover, Jr., labor	37 00
Aug.	22. Henry A. Dreer, turnip seed	39
Nov.	12. Fall Creek Milling Co., feed	13 50
Oct.	19. Egbert & Merrill, drugs and chemicals	5 23
Dec.	31. Ira A. Grover, Jr., labor	37 00
	6. W. O. Wyckoff, stationery	1 25
Aug.	15. E. McGillivray, photo plates	1 32
July	9. H. W. Bostwick, baskets	4 00
Dec.	18. Fall Creek Milling Co., feed	12 30
Sept.	25. Pritchard & Son, repairing wagons	15 10
1895.		
Jan.	1. Burns Bros., shoeing horses	1 70
	29. August Roelker & Sons, chemicals	2 79
Feb.	1. Ira A. Grover, Jr., labor	38 42
	8. D., L. & W. R. R. Co., freight	1 25

1895.			
Feb.	8.	D., L. & W. R. R. Co., freight	$0 77
	2.	M. E. Jones, labor	3 00
	18.	National Express Co., expressage	25
	28.	Ira A. Grover, Jr,, labor	37 00
	28.	Peter C. Toner, labor	40 00
April	1.	Ira A. Grover, Jr., labor	37 50
	1.	Peter C. Toner, labor	40 00
Feb.	6.	H. Cannells & Sons, begonia plants	4 32
	2.	White & Burdick, chemicals	1 60
	27.	Alfred Bridgeman, seed beans	2 00
March	22.	J. W. Austin, dewberry plants	1 00
	13.	J. W. Killer, hazel plants	1 20
	14.	Rochester Lith. Co., hand plates	42
	14.	Driscoll Bros., sand and lime	3 00
April	10.	W. M. King, cherry tree	3 00
	30.	J. A. Stevenson, oats	21 32
	30.	Ira A. Grover, Jr., labor	37 50
	30.	Peter C. Toner, labor	40 00
1894.			
May	1.	Gustav E. Stechert, foreign periodicals	26 50
1895.			
Jan.	23.	Edward G. Allen, foreign periodicals	11 48
May	31.	Peter C. Toner, labor	16 00
	31.	Ira Grover, Jr., labor	37 50
1894.			
Nov.	15.	Ellwanzer & Barry, strawberry plants	1 50
1895.			
June	3.	J. W. Manning, hay	8 10
May	6.	J. F. Moore, harness sundries	8 45

1895.			
June	1.	E. C. Cleaves, blue print paper..........	$10 06
	29.	Ira Grover, Jr., labor....................	37 50
	29.	Peter C. Toner, labor....................	40 00
		Total for horticultural division..........	$1,061 95

For Chemical Division.

1894.			
July	12.	C. U. Chemical Department, chemicals...	$53 38
	12.	White & Burdick, chemicals..............	4 55
Oct.	2.	National Express Co., expressage........	65
Nov.	6.	W. W. Root, labor......................	4 70
Dec.	4.	W. W. Root, labor......................	21 60
	1.	C. U. repairs, stock and labor.............	1 84
Nov	21.	Jameson & McKinney, plumbing..........	28 63
1895.			
Jan.	2.	W. W. Root, labor......................	26 25
Feb.	2.	W. W. Root, labor......................	12 50
March	5.	Ithaca Plumbing Co., plumbing..........	1 39
June	29.	C. U. Chemical Department, gas..........	26 91
		Total for chemical department.........	$182 40

For Botanical Division.

1894.			
July	11.	J. B. McAllister, meat..................	$0 40
	11.	Larkin Bros., groceries..................	15
Sept.	24.	Treman, King & Co.,galvanized condenser,	2 25
	29.	Jamieson & McKinney, rubber tubing.....	3 50
Oct.	15.	E. McGillivray, photo supplies............	28 92
	12.	Eimer & Amend, chemicals..............	14 80

1894.			
Sept.	18.	White & Burdick, chemicals	$1 30
Oct.	26.	The Bool Co., furniture and repairs	34 28
Nov.	7.	R. H. Pettit, labor	10 60
	7.	Bertha Stoneman, labor	5 00
Oct.	20.	Bausch & Lomb Opt. Co., chemicals	3 45
Dec.	19.	Andrus & Church, stationery	9 73
	21.	Bertha Stoneman, labor	11 00
	29.	E. McGillivray, photo supplies	9 91
	19.	G. F. Atkinson, stamps and traveling expenses	16 41
	6.	Eimer & Amend, chemicals	11 00
1895.			
Jan.	7.	W. W. Calkins, collection lichens	37 00
	10.	Andrus & Church, stationery	2 78
	31.	Mary A. Nichols, labor	4 60
	31.	Bertha Stoneman, labor	22 00
	5.	Treman, King & Co., hardware	9 10
Feb.	2.	A. B. Langlois, pyrenomycetes	12 00
	20.	Whittle, Tatum & Co., glass vials	1 50
Jan.	11.	E. McGillivray, photo supplies	6 35
April	3.	Mary A. Nichols, labor	7 20
	3.	Bertha Stoneman, labor	13 60
	2.	Andrus & Church, stationery	3 00
March	14.	Andrus & Church, printed letter heads	3 00
	11.	White & Burdick, chemicals	6 95
Feb.	5.	E. Larkin, potatoes	15
March	2.	The Bool Co., reseating chair	85
Feb.	4.	Andrus & Church, stationery	95
April	6.	Andrus & Church, stationery	35

1895.			
April	8.	B. Fink, 171 packages of lichens..........	$8 55
Feb.	28.	Gustav E. Stechert, foreign periodicals...	13 56
1894.			
Oct.	24.	Gustav E. Stechert, foreign periodicals.....	3 24
May	11.	Charles Scribner Sons, periodicals........	3 60
1895.			
May	17.	Mary A. Nichols, labor....................	4 40
	17.	Bertha Stoneman, labor..................	9 00
	28.	White & Burdick, chemicals..............	5 95
	25.	E. McGillivray, photo supplies............	2 70
March	21.	Enz & Miller, stationery.................	6 00
June	8.	Eimer & Amend, chemicals..............	19 50
	18.	Eimer & Amend, chemicals...............	7 75
	13.	B. Westerman & Co., periodicals..........	1 00
May	31.	E. Steiger & Co., periodicals..............	3 50
	7.	Andrus & Church, stationery.............	3 05
June	17.	Whitall, Tatum & Co., glassware.........	9 39
		Total for botanical division............	$395 27

For Entomological Division.

1894.			
July	1.	Treman, King & Co., hardware...........	$1 20
	27.	National Express Co., expressage.........	1 35
	25.	U. S. P. O., 500 stamped envelopes........	10 90
	26.	Library Bureau, card index case and accessories..............................	14 33
	25.	J. Carbutt, photo plates..................	4 00
	19.	J. D. Eagles, Ferro plates................	50

1894.

Aug.	1.	M. V. Slingerland, expressage	$1 00
	1.	C. U. Farm, labor	65
	5.	G. W. Herrick, labor	23 05
		U. S. Express Co., expressage	60
	29.	G. W. Herrick, labor	24 85
Sept.	1.	C. U. Farm, labor	91
Jan.	27.	White & Burdick, chemicals	3 80
Sept.	17.	Andrus & Church, stationery	70
	26.	G. W. Herrick, labor	9 20
	21.	The Bool Co., office chair	5 50
	21.	Holmes Hollister, lumber	47
	18.	Edward R. Taylor, carbon bi-sulphide	65
	21.	Rothschild Bros., lamp fixtures	1 18
Aug.	11.	E. McGillivray, photo supplies	4 00
Sept.	21.	Andrus & Church, stationery	30
	24.	D., L. & W. R. R. Co., freight	63
	20.	Treman, King & Co., hardware	1 35
Oct.	6.	Peter Henderson & Co., bulbs	2 95
	8.	Andrus & Church, stationery	1 00
July	7.	Treman, King & Co., hardware	15
Oct.	31.	Rothschild Bros., candles	1 00
	31.	G. W. Herrick, labor	9 95
Nov.	14.	U. S. Dept. Agriculture, index cards	2 00
	24.	G. W. Herrick, labor	7 10
	27.	National Express Co., expressage	85
Dec.	8.	Andrus & Church, printed letter heads and stationery	7 25
	22.	G. W. Herrick, labor	7 00
Sept.	21.	A. B. Brooks, chemicals	6 37

1895.

Jan.	5.	G. W. Herrick, labor	$5 90
	5.	Andrus & Church, mucilage	1 10
	8.	U. S. Express Co., expressage	70
	21.	U. S. Express Co., expressage	25
	7.	J. Carbutt, photo plates	5 38
	25.	G. W. Herrick, labor	7 90
	23.	U. S. Express Co., expressage	25
	25.	U. S. Dept. Agriculture, index cards	2 00
Feb.	1.	Andrus & Church, drawing ink	75
	16.	G. W. Herrick, labor	4 60
	22.	U. S. Express Co., expressage	45
	28.	G. W. Herrick, labor	5 00
	2.	Jamieson & McKinney, plumbing	2 44
March	4.	Andrus & Church, catalogue cards	1 25
	22.	G. W. Herrick, labor	5 45
	28.	L. V. R. R. Co., freight	50
	29.	Hammond & Willard, peach trees	2 55
April	6.	G. W. Herrick, labor	9 95
	6.	E. McGillivray, chemicals	60
March	26.	Treman, King & Co., glass	1 35
April	9.	G. Cramer, photo plates	2 94
	20.	L. V. R. R. Co., freight	50
	26.	National Express Co., expressage	70
	17.	Hammond & Willard, fruit trees	65
	23.	G. Cramer, photo plates	5 22
	22.	Andrus & Church, stationery	50
	13.	Treman, King & Co., basket	25
	29.	G. W. Herrick, labor	4 00
May	1.	U. S. P. O., postal cards	5 00

1895.			
May	3.	E., C. & N. R. R. Co., freight	$0 61
	2.	Andrus & Church, printing	1 00
	18.	G. W. Herrick, labor	4 20
	27.	U. S. Dept. Agriculture, index cards	2 00
June	8.	U. S. Express Co., expressage	1 25
	6.	The Deming Co., repairing spray pump	5 00
	17.	National Express Co., expressage	25
	6.	Arthur B. Brooks, chemicals	4 77
	29.	H. G. Norwood, labor	5 09
	27.	Treman, King & Co., hardware	5 32
		Total for entomological division	$264 36

SUMMARY.

The Agricultural Experiment Station of Cornell University, in account with the United States Appropriation:

DR.

To receipts from treasurer of the United States as per appropriation, for the year ending June 30, 1895, under act of Congress, approved March 2, 1887	$13,500 00

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Salaries	$8,205 04
Buildings	267 65
Printing	1,910 99
Office expenses	645 72
Equipment, labor and current expenses:	
Agriculture	566 62
Horticulture	1,061 95

Chemistry	$182 40
Botany	395 27
Entomology	264 36
	$13,500 00

Receipts for produce sold:

Balance from 1893-94	$841 44
Horticultural division	87 86
Office	1 00
	$930 30
By printing *	$336 52
By balance to 1895-96	593 78
	$930 30

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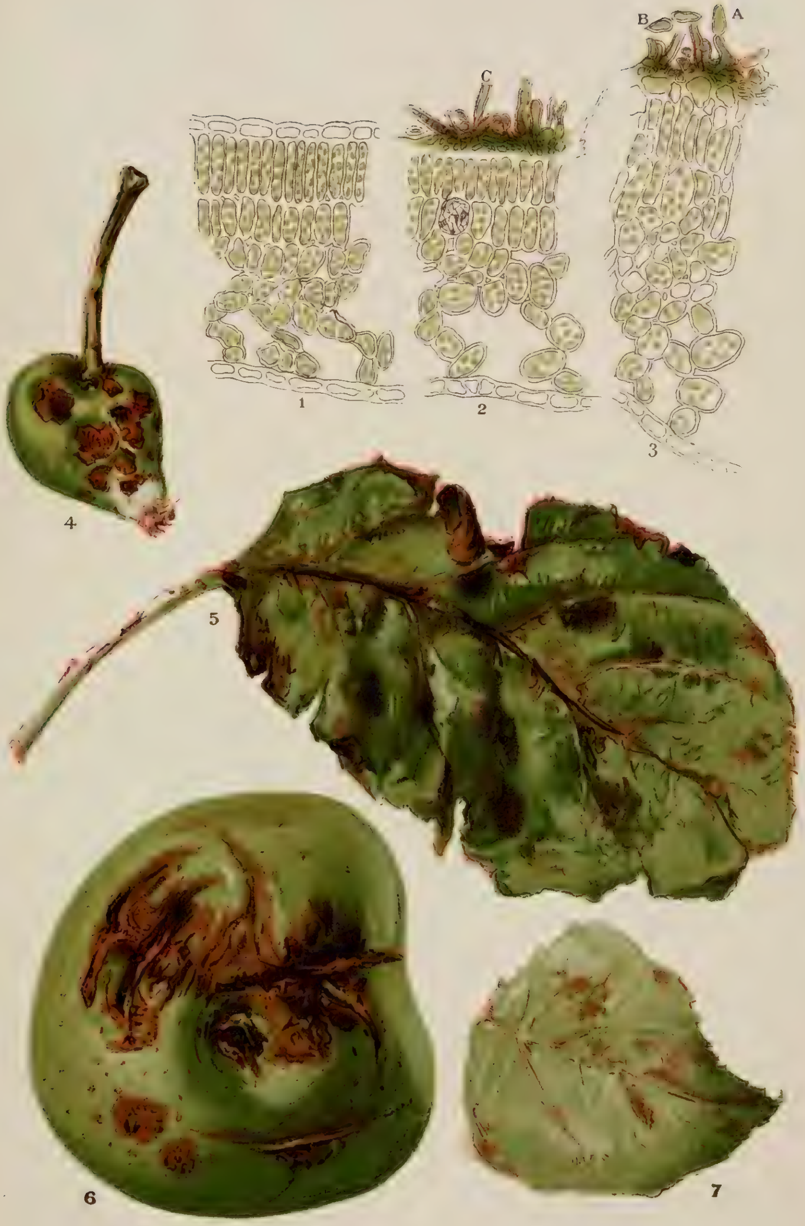
* Electros, cuts and printing 10,200 copies Bulletin No. 94, $335.72 ; expressage, $0.80 ; total, $336.52.



THE APPLE SCAB FUNGUS.

BULLETIN 84 January, 1895.

Cornell University—Agricultural Experiment Station.
HORTICULTURAL DIVISION.

The Recent Apple Failures

OF WESTERN NEW YORK.

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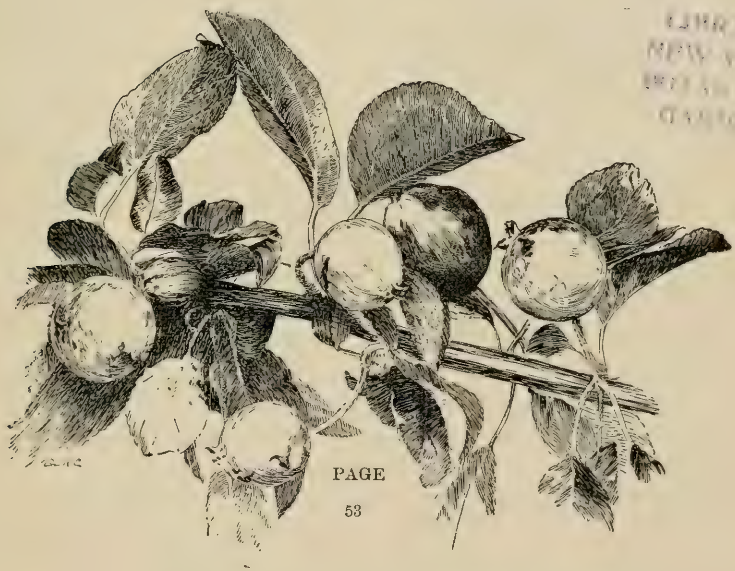

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By L. H. Bailey.

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BULLETINS OF 1895.

84. The Recent Apple Failures in Western New York.

Cornell University,
Ithaca, N. Y., *January* 15, 1895.

The Honorable Commissioner of Agriculture, Albany:

Sir.— The most important fruit interest of western New York is apple growing, and it is also the one which has been subject to the most disastrous failures during the past decade. I have attempted to discover the causes of these failures, and the larger part of last summer was spent in a careful examination of apple orchards in various parts of the Fifth Judicial Department; and experiments in the fertilizing of orchards were inaugurated. It was the original intention to present a full account of these surveys, describing specific cases both of failure and success in apple-growing; but the account would be so voluminous that I forbear, and I now submit the summary conclusions of the investigation. The statement is proposed for publication under Section 87, Chapter 675, of the Laws of 1894. A detailed sketch of spraying experiments of the year will appear in Bulletin 85. A synoptical guide for the operator will be found in the new Spray Calendar.

L. H. BAILEY.

Overloaded with Kings. W. T. Mann. (See page 70.)

I. A renovated orchard. Sorting-table in the foreground. Albert Wood. (See page 74.)

The Recent Apple Failures of Western New York.

The causes of the failures of our apple orchards are various, and it is likely that many of them are not understood or even known. I am satisfied that the first and fundamental cause is neglect. For twenty years and more, our apple growers have sown neglect; they are now reaping the harvest.

More than half the apple orchards of western New York have been turned out to grass from the time they were set; and even the grass has too often been sold at the city market. Land will not grow good meadows and good orchards at the same time. The grass takes the cream of the land. Apple trees which have been fed on skim milk for a quarter of a century must be expected to be lean.

If grass has not been profitable, the orchard lands may have been sown to grain, and the farmer usually complains if the grain is not a good crop. The trees are not thought of as requiring ground space and food. Orchardists generally consider, too, that the crop, in an apple orchard, is the fruit; but the crop is really the orchard itself, for the soil must nourish the trees day by day, just as it nourishes a crop of corn or hay. The orchard is a continuous crop upon the land, whether it bears or not. The most delicate morsels of the soil are taken by the wheat and oats; and these plants appropriate the water from the rains and there is no tillage to conserve soil-moisture. The apple trees feed upon the husks, and are then obliged to share their portion with borers, tent caterpillars, fungi, and twenty other tramps.

Of late years, attention has been given almost wholly to these tramps, by the use of the sprays. This is essential; but it is evident that this is not the primary or fundamental treatment for an apple orchard. Food and moisture are the first considerations.

People say that spraying is not always sure to bring a crop. Certainly not! One can not feed a horse by using a curry comb. It is a wonder that, in the average orchard, the spray is ever sufficient to secure a crop; but the fact that it often is, is proof of the wonderful constitutional vigor of an apple tree and the pertinacity with which it holds on under discouragement.

Some persons who have cultivated, fed and pruned their orchards for the past few years, and have sprayed in the bargain, have yet failed to secure good crops. This is not surprising. One should not expect to correct the evils of years of neglect by a spurt of repentance; and the evil is the worse, too, for having been wrought when the orchard was young, for "as the twig is bent, the tree's inclined." Orchards which have been many years in sod and neglect are occasionally thrown into such exuberant growth by tillage and fertilizing that they do not bear. Such a change would, no doubt, be a surprise to most western New York orchards, and it would be no wonder if the trees should jump out of their boots. In such case the orchardist should aim at a moderate growth by stopping cultivation early in the season (say the middle or last of July) and by the sparing use of nitrogenous fertilizers. Yet this treatment — liberal tillage, fertilizing, pruning and spraying — is the best which can be recommended for old and unprofitable plantations, and if it will not revive the old trees the only remaining treatment is to plant a new orchard.

So long as trees blossom profusely, they should bear. Perhaps the bloom oftenest fails because of the attacks of the apple-scab fungus, an opinion which was first expressed, so far as I know, in our Bulletin 19, which was devoted to the fruit failures of 1890 in western New York. When this is the case, Bordeaux mixture is a specific. Frequently, the trouble is the codlin-moth worm or other insects, and for these Paris green is a specific. But the flowers probably often fail to set fruit because the tree is not sufficiently nourished to sustain them. Unfortunately, there is no complete specific for this difficulty, for the orchard may be in such condition, from long neglect, that the land can not be properly tilled and the trees can not be adequately fed. One of the best methods of feeding the tree is to keep it well pruned, for the food which is diffused in numbers of worthless limbs is then concentrated in a small number. And it is only the well pruned trees which are capable of successful treatment with the sprays.

Good tillage should be the first intention of the apple grower. But this can be satisfactorily given only in orchards which have been properly planted. The roots should be deep enough to allow of easy plowing, not only because the tillage may thereby be improved, but also because the roots are then in moister earth and they suffer less from dry weather. Planters frequently make the mistake of setting their trees too shallow. It is probably better to have them stand rather deeper in the orchard than they did in the nursery; but whatever depth the person may design to plant them, he should make allowance for the settling of the soil. Land which has been for some years in pasture, meadow, or grain, is elevated or loosened by plowing, and it frequently requires an entire season of good tillage to compact it to its normal level. But the trees are set in the subsoil, and therefore do not settle; and the owner may find at the end of a year or two that his trees seem to stand too high out of the ground. When setting trees on newly turned land, the planter should allow one or two inches for the settling of the soil, and thereby increase the depth of the planting.

Now, if the soil is deep and well drained, and the trees are properly planted, rather deep spring plowing is recommended for the first few years. The exact depth to which the furrow may be run will depend much upon the soil, but it should rarely exceed seven or eight inches. It is probably best to plow apple orchards early in the spring, but not in the fall unless it may be found, by experiment, that plowing under the leaves in the fall lessens the attacks of apple scab. Fall plowing leaves the surface in bad shape for the winter, and it serves no purpose. Yet it should be said that apple orchards are less likely to suffer from fall plowing than many other kinds of fruits, for the trees are hardy, and not likely to be forced into fall growth and are not induced to start so early in the spring as to be caught by frosts. But there is no occasion for plowing apple orchards in the fall, as a rule, so far as we know.

Till the soil frequently and lightly during the late spring and early summer. The general methods of cultivating orchards, and the reasons for them, are discussed in Bulletin 72, to which the reader is referred; but the leading points may be reviewed here.

Let us first consider the relation of tillage to moisture. The land obtains its water from rains. This water is held in the interstices of the soil, and it gradually passes off into the air by evaporation. In finely compacted soils, the water which is in the lower levels is gradually raised to the surface by capillary attraction. A mulch of straw placed upon the surface, prevents this soil moisture from coming into immediate contact with the atmosphere and it therefore keeps the soil moist. Two to four inches of loose fine earth acts in essentially the same manner,—it mulches the soil beneath by breaking up capillary attraction, and preventing the soil moisture from reaching the atmosphere. This loose top soil may itself be as dry as ashes, but it still conserves the moisture beneath. Every farmer knows that a "baked" soil soon becomes dry; and he also knows that the soil underneath a well-tilled surface is always moist. It is evident that, if one wishes to conserve the greatest amount of moisture, he must begin his tillage early and he must continue it uninterruptedly throughout the season. Above all things, he will cultivate soon after a rain, to prevent a crust from forming. The past season was one of almost unprecedented drought in New York. Most farmers suffered severely, and as a result the winter meetings are full of discussions of methods of irrigating lands. But the best irrigation in this State, for orchards, is frequent shallow cultivation —repeated every week or ten days so long as one wishes to keep his trees growing. The long dry seasons of California are made fruitful by constant tillage. By its use, orchards are now growing profitably without irrigation in certain western lands where the annual rainfall is said to be less than ten inches. With our thirty to fifty inches of rainfall, there is little need for irrigating orchard lands, if we take care of the water which we have. In the burning heats of last summer, when everyone was asking for water, I visited a raspberry grower, upon sandy soil, who was afraid it would rain and spoil his berries! His patch was crisp and fresh and loaded with fruit. "But you must have rain to ripen your crop," I said. "No," he replied, "drought never affects me. I water my land with the cultivator."

But tillage means more than conservation of moisture. It promotes nitrification and enables the plant to unlock more of the mineral elements than it otherwise could do. Every good soil is a mine of plant food, and the first thought of the farmer should be to utilize it. The buying of fertilizers should be a second thought. As a rule, an orchard should never be seeded down; or if sod appears to be necessary, pasture it close. Do not make a meadow of the orchard nor attempt to raise grain in it, even from the beginning. Hoed crops may be grown during the first few years, if one cultivates well and allows sufficient space about the trees—and tree roots extend much farther than farmers are aware—but the temptation is to continue the practice too long and to expect too much from the crop. If the trees are to be of secondary importance, do not plant them! It will be cheaper to leave them in the nursery.

Persons often tell me that they know of productive orchards standing in sod. So do I; but this only proves that the land is unusually good. The great majority of orchards contradict this experience, and reason is against it. For myself, I should consider that I could not afford to run the risk of placing orchards permanently in sod. There are cases in which thrifty young orchards can be thrown into bearing by seeding them down, but this is only a temporary expedient, and if the land is again brought under cultivation when the desired result is obtained, no harm will come. If the old orchard is giving satisfactory returns in sod, it would be folly to plow it up; but if it is unprofitable, something must be done. Next to tillage, pasturing closely with sheep or hogs is the best thing which can be done; and if the stock is fed grain, so much the better.

Thus far, I have spoken of apple orchards which have been under good treatment from the first. How shall we manage the old orchards, which have been neglected for years? Such orchards, of course, are in sod. The roots are so high that the land cannot be plowed. In this case, the best that can be done is to break up the turf in spring when it is soft, using a sharp toothed or disc harrow. When the sod is once well cut up, sow on fertilizers, and continue to work it shallow. But the tree tops are often so low that a team can not be used. An orchard in which horses can not be driven is worth little, and it is doubtful how much labor can be spent upon it with profit. Trees which have been cultivated from the first have their tops formed by gradual and timely prunings, the owner scarcely knows how; but the untilled trees often develop into brushheaps, which no amount of good intentions can correct. But, if possible, these old orchards must be trimmed up to admit of cultivation. Swine can sometimes be utilized as plows in such orchards. With a crowbar make holes three or four inches deep all through the orchard and drop a handful of corn or buckwheat in each hole. Let the hogs root for it!

As to fertilizers for the apple orchards, little can be said within the limits of this paper. In orchards which have been well tilled from the first, there will seldom be any need to add much, if any, commercial nitrogen. If the trees apparently need it, a sufficient supply may usually be had from the use of crimson clover (see Bulletin 72). Potash is considered to be the dominant factor in fruit production; this and phosphoric acid should be added each year. In using concentrated fertilizers, the grower should bear in mind that his object is to feed the plant, not to fertilize the soil. That is, it is better to add each year about as much as the plant may be supposed to need, rather than to occasionally apply a surplus with the idea that it will be of use in future years. It is true that the best effect of fertilizers may appear in the second or even in the third year after application, but this does not affect the proposition. It is also true that potash and phosphoric acid do not escape from the soil, as nitrogen does; but any superfluous amount is likely to become more or less mechanically locked up in clods of earth, and it may be shifted by the movements of soil water. And there are some plants, at least, which take up more phosphoric acid than they need, when this material is applied in redundant amounts. At all events, if I had more commercial fertilizer than the trees would evidently need, I should rather have it in the barn than in the ground.

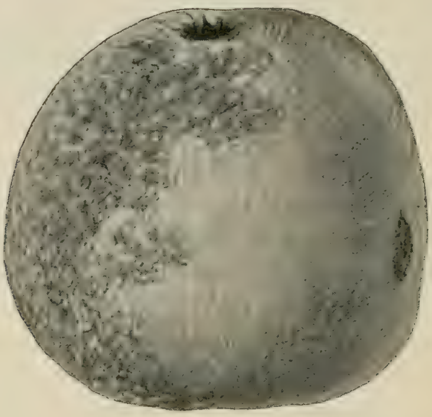
But the immediate cause of most of our apple failures of the last few years, is undoubtedly the apple-scab fungus. In the first place, it should be said, however, that only a small part of the flowers, when the bloom is full, should be expected to set fruit. Apple flowers are borne in clusters of six to twelve, but the apples are usually borne singly. These superfluous flowers undoubtedly furnish pollen for the ones that set. The picture shows the normal blasting of the flowers. This cluster had seven flowers, and six of them are now withered and dead, whilst the seventh has passed into an ambitious apple. Many of the one-sided apples owe their deformity to imperfect pollination. Such a one is shown in the cut. The apple has five carpels or cells, each cell containing, normally, twin seeds. Now each of these twins is fertilized by pollen which falls upon that one of five stigmas which is attached to that carpel; and if no pollen falls upon this particular stigma, the seeds will not develop and the apple grows slowly upon that side.

2. Normal failure of apple flowers. Only one has set fruit.

This apple scab is no new pest. It has no doubt been seriously present ever since apples were grown in the country, causing many failures of crops which were laid to the weather or the moon. But within the last decade, it seems to have been unusually destructive in the orchards of western New York. It is now enforcing attention to the condition of our long neglected orchards, and it will undoubtedly be the means of greatly improving the apple industry of the country. It is most familiar in the scab-like patches upon the fruit. The small scabs upon mature apples are probably due to infections rather late in the season. If the fungus attacks the fruit when it begins to grow, the apple may become one-sided, and later on it may crack; or the apple dies and falls. The earlier the apple is attacked, the greater is the injury,

3. Lop-sided apple, due to imperfect pollination.

and, as a rule, the very earliest attacks in bad seasons, are fatal. Various stages of injury upon the fruit are shown in the colored plate. Fig. 4 shows a Northern Spy taken July 5th, last year. This apple is now deformed by the attacks of the scab, and if it had remained upon the tree it would probably have become a gnarly, crooked specimen entirely unfit for use. It is probable, however, that the fungus patches upon the stem would have soon cut off the food supply, causing the apple to fall. Fig. 6 is a Greening picked September 20th. The deep fissures have resulted from the checking of the growth of the fruit by the fungus. At the lower side of the apple are shown two small scabs which are dead and harmless. The tissues of the apple have grown beneath them, and have broken them apart.

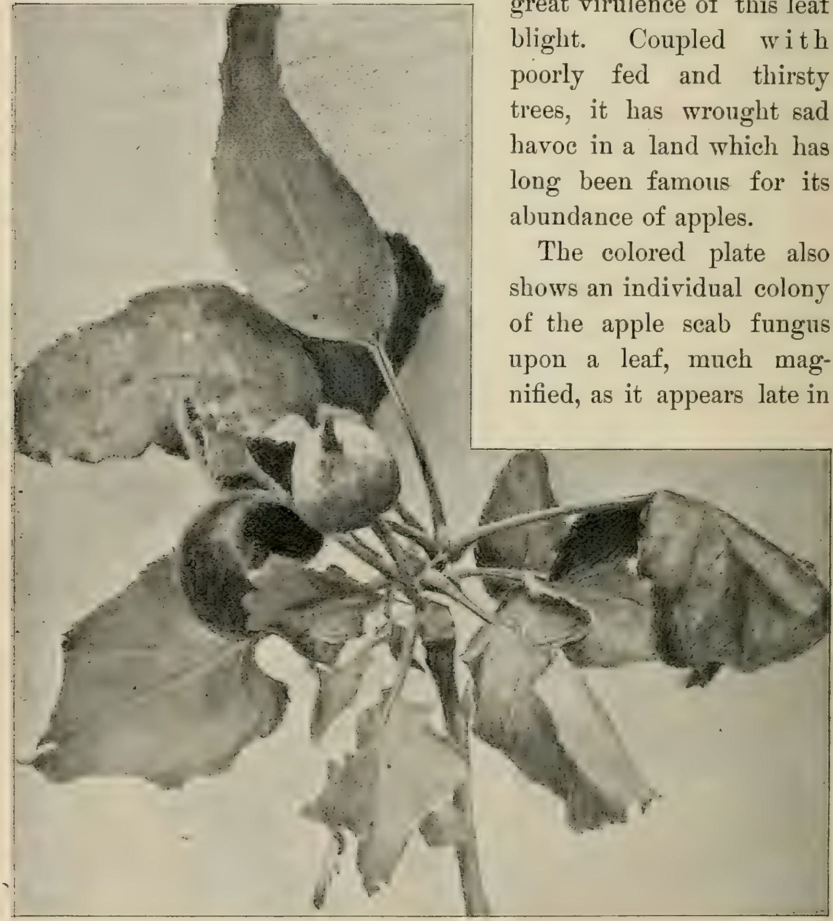


4. Apple injured by Bourdeaux mixture.

During the past summer, this scab upon the fruit has been confounded by some persons with an injury wrought by the Bordeaux mixture itself. This injury is a russeted surface of the apple upon the sprayed side, much like that shown in the accompanying illustration. It appears to come mostly from the use of Bordeaux mixture which has an insufficient supply of lime to satisfy the reactions which occur, in a wet season, after the mixture is applied to the tree. In seasons like the last, the use of the ferrocyanide of potassium test for the preparation of Bordeaux mixture is probably unsafe. This injury is not often serious, and the fruit more or less out-grows it; but I have seen a number of cases during the past season in which I was satisfied that the mixture had been the cause of the dropping of the fruit. Pears seem to suffer most, and in some instances, the crop was nearly ruined by the spray. The climatic conditions which made this injury possible may not recur in many years, but last year's experience in western New York has taught the importance of using freely of lime in the preparation of Bordeaux mixture. There was more or less of this russett injury upon many orchards sprayed with the Bordeaux mixture made by the regular formula, and it was even often present upon unsprayed trees. It is evident that the weather was sometimes directly responsible for it, but the injury was never serious, so far as we could determine, except upon those trees which were treated with the mixture made with the ferrocyanide test. A similar effect of the Bordeaux or the arsenic was common upon the foliage of the sprayed trees, the injury appearing in the form of circular dead, brown spots, but even in the worst cases which I saw the leaves were much less injured than they evidently would have been by the fungus. A fuller discussion of this matter will occur in Bulletin 85. For an account of a similiar injury upon the quince, see Bulletin 80.

The most serious injury wrought by the fungus in western New York in recent years is upon the foliage. Its first visible attack, upon the under side of a leaf in this case, is shown in Fig. 7 in the colored plate. It is simply a light olive-green discoloration, appearing in small patches. Fig. 5 is a leaf badly attacked in many places, chiefly among the veins, where the disease causes dark, sooty elevations; and patches of it are often seen on the leaf stalk. The lumpy character of these patches is perhaps a trifle exaggerated in the printing of the plate, but otherwise the picture accurately represents a leaf badly attacked by the fungus. These attacks cut off the food supply of the parts of the leaf beyond, and the leaf becomes dry and curled, its edges die and are torn by the wind, giving the tree the blighted appearance which is familiar to all New York apple growers. A spray of this ragged, blighted foliage is shown in the illustration on the next page. This condition of the foliage is often serious even when the apples themselves are very slightly attacked, and it is sometimes so bad that most of the foliage falls in early summer. It has been at its worst early in the season during the past few years, no doubt because the weather has been favorable to its spread when the foliage is young. It is evident that trees with such foliage as this can neither mature a crop of apples nor lay up much store of energy for the following year. Those not familiar with the conditions in western New York, can have little idea of the wide-spread prevalence and great virulence of this leaf blight. Coupled with poorly fed and thirsty trees, it has wrought sad havoc in a land which has long been famous for its abundance of apples.

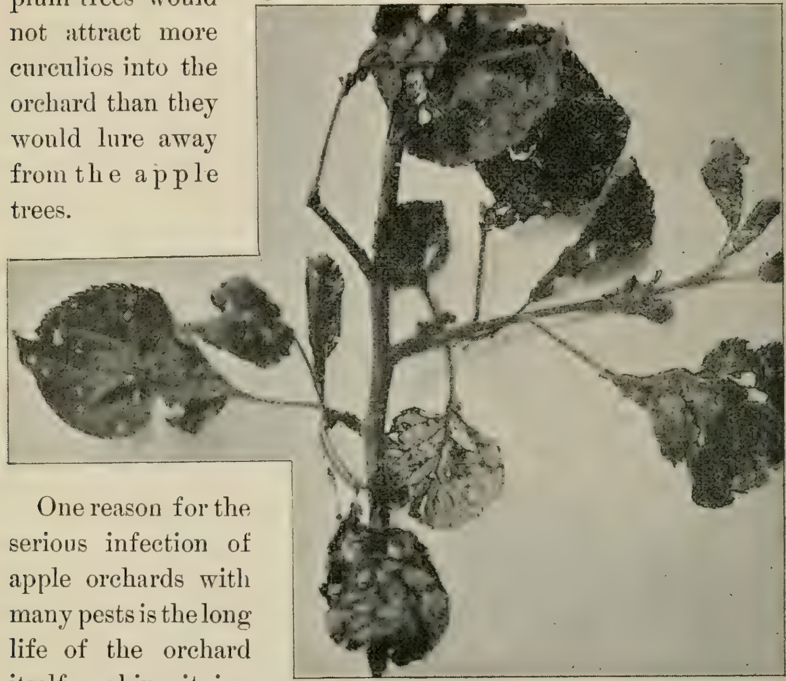
The colored plate also shows an individual colony of the apple scab fungus upon a leaf, much magnified, as it appears late in the season. Figs. 1, 2, and 3 represent cross sections of a leaf. In Fig. 1 the leaf is healthy. Observe the regularity of the three upper layers of cells. In Fig. 2, the brown fungus may be seen



5. Blighted foliage of Fall Pippin, taken June 29.

growing on the upper surface, and at this date it has destroyed the upper or epidermal cells, although it is probable that the mycelium of the fungus first spreads just under the cuticle, on top of the layer of epidermal cells. Fig. 3 shows the fungus when it is better established, and it will be seen that all the cells of the leaf are disarranged, the chlorophyll or green grains being few in number, and the leaf has increased in thickness. This Fig. 3 is a cross section through one of the blister-like elevations which are shown on the leaf in Fig. 5. It will be seen that the fungus does not enter the deeper tissues of the leaf, although it disorganizes them by its parasitic effects. In Fig. 3, a spore can be seen at A, and two are shown broken off their stems or hyphæ, at B. In Fig. 2, the spores can be seen in process of formation at the ends of the threads, and at C one of the threads is cut off. The fungus itself is supposed to pass the winter on young shoots, fallen leaves, and upon the fruit. The spores form at a low temperature, and the early cold wet weather of recent years has afforded excellent conditions for the spread of the fungus. The apple scab is one of the so-called "imperfect fungi,"—a name given to those fungi of which the perfect form is unknown. The reader will recall that some fungi, like the quince rust (see Bulletin 80), have two very unlike forms which sometimes live upon different plants. There is every reason to expect that the apple scab passes part of its existence in another form; and it is possible that the discovery of this other form may give us a new means of combatting the disease.

Various insects cause the occasional failure of the apple crop over considerable areas. One of the worst of these in western New York is the bud-moth (see Bulletin 50). Another one, which was serious in Wayne and Monroe counties last year, is the cigar-shaped case-bearer (*Coleophora Fletcherella*), an acccount of which may be expected later on from the Entomological Division. The work of this insect upon the foliage is shown on the next page. The plum curculio has also been a serious pest upon apples in some places, puncturing the apples and causing them to grow gnarly. Its marks may be seen upon two of the young apples shown on the cover. The apple-worm, the larva of the codlin moth, is too familiar to need description, and is now pretty generally held in check by Paris green. The same remedy will also apply to the bud-moth and case-bearer. For the curculio, there is no good remedy upon the apple. It is doubtful if its numbers are greatly lessened by arsenical sprays. Some persons have recommended the planting of plum trees in the apple orchard for the purpose of attracting the curculios, and from these trees the insects can be jarred onto sheets. It is a question, however, if the plum trees would not attract more curculios into the orchard than they would lure away from the apple trees.



6. Work of the cigar-shaped case-bearer. June 14.

One reason for the serious infection of apple orchards with many pests is the long life of the orchard itself, making it impossible to rotate the crop. It is well known that a frequent and proper rotation of crops is one of the most efficient means of keeping insects and fungi in check. This is true even of small-fruit plantations. Our best blackberry and raspberry growers, in regions where there is likely to be trouble with anthracnose and root-galls, fruit their plantations only two or three years, and by the time the enemies become threatening the patch is destroyed. But with apple orchards this is impossible. The large, thick-topped trees become unmolested breeding places for disease decade after decade. So orchards, of all other crops, should receive the most painstaking treatment for insects and fungi.

7. Apples that pay. T. G. Yeomans & Sons. (See page 68.)

The best proof that the apple scab fungus is the immediate cause of the greater part of the apple failures of western New York is afforded by the fact that thorough spraying with Bordeaux mixture is usually followed by a great increase in the productiveness of the orchard ; and it may be said that the indifferent results which occasionally follow the spray are equal proofs that there may be other causes than the fungus for the failures. Much of the failure with the Bordeaux mixture, however, is due to careless or hasty application. If the Bordeaux mixture is properly made — using an excess of lime — no injury may be expected to follow its use, and it should be applied with great thoroughness. The operator should endeavor to completely cover all the leaves and shoots. A mere sprinkling, such as most persons give, is of little good. One thorough application, which drenches the tree, is better than several of this ordinary kind. Then people are always waiting for fair weather. Now, it is in the rainy weather that the fungi spread most seriously, and it is then that the spray is most needed. With plenty of lime the mixture adheres well. Spray between the showers, even when the trees are wet, if you can do no better. To delay is to fail. It is better to spray in the rain than not to spray at all.

There is abundant proof that two to four applications of Bordeaux mixture are capable of keeping the fungus almost completely in check. It is not known what value there is in an application before the buds open, but it can do no harm, and it is probable that it is very serviceable in most seasons. At the latest, spraying should begin as soon as the blossoms fall. Make the Bordeaux mixture with 6 pounds of copper sulphate, 4 pounds (or more if the lime is air-slacked) of lime and about 40 gallons of water. It is always advisable to add Paris green for various insects — 1 pound to every 250 gallons of the mixture. Then take up your position near the tree with a strong pump and apply the mixture until the tree is soused.

Does the Bordeaux mixture kill the scab fungus, or simply keep it off? To test this matter, marked leaves and fruits were immersed, upon the tree, in Bordeaux mixture on June 20, July 4, and July 26. All the leaves and fruits were badly attacked with the fungus at the time of the first application. Without going into details, it may be said that none of the treated leaves recovered from the attacks of the fungus, but most of them were in better condition when growth had ceased, in August, than similar check leaves upon the same shoots. Those which were so badly diseased when the experiment began that the edges had begun to roll or curl, fell off in July, whether treated or not. The only very marked benefit coming from the treatments of Bordeaux upon leaves, was seen in the case of two similar large leaves of Siberian Crab, standing side by side. When the experiment was begun, these leaves were just beginning to show the debility due to the infection of scab, but no definite scab patches had developed. One leaf was treated, and the other not. When the second application was made, two weeks later, no difference could be detected between the two leaves, and the disease had progressed little. But from this time on, the treated leaf suffered little extension of the disease, but the other developed scab-patches, and prominent blisters raised upon the upper surface, the leaf finally appearing much like Fig. 5 in the colored plate. Upon the young fruits there was a more distinct benefit from the treatment. In every case, the Bordeaux confined the spots to very nearly their original dimensions, and in one or two cases the scab was wholly killed. On one fruit of Siberian Crab, there were several scab-patches an eighth of an inch across when the treatment began. These spots had not enlarged two weeks later, and a month after the first treatment—the apple having been dipped twice in Bordeaux—the patches appeared to be dead, but a new growth of the fungus had started beyond the rims of the original spots. In another case, five scabby apples upon one twig were treated the three times, and on two of the fruits the scab was certainly wholly killed, notwithstanding that the injury at the time of the first treatment was quite as serious as that upon Fig. 4 in the colored plate. The patches of scab broke away, the apple resumed its growth underneath, and in their places there appeared a scabby russet surface like that made by the injury of the Bordeaux mixture (as described on p. 60.) In one case, in which the spots of scab had nearly encircled the little fruit, the apple grew most rapidly upon either end, leaving a russet valley or zone extending nearly around the fruit. But if anything was gained by the killing of the scab, it was generally lost by the injury of the Bordeaux mixture itself, for half of the treated apples finally dropped. It will be recalled that these apples were immersed, the mixture being held in a cup, and the fruits were allowed to lie in it a half minute at each of the three applications. Some of the apples did not appear to be injured by this treatment, but many of them evidently were. I have made careful examinations of the young apples in sprayed orchards, and I am satisfied that the small and recent patches of scab are sometimes killed outright, but the chief value of the Bordeaux mixture certainly lies in preventing an attack or checking the spread of the fungus.

Apples can still be profitably grown in western New York. This is proved by the experience of a number of orchardists. I have visited over twenty orchards in the western part of the State this year in which there were large crops of excellent quality, but all of these had been sprayed with Paris green or Bordeaux mixture, or both, all of them were pruned and the land was in "good heart." Most of them were cultivated. The general run of orchards were almost barren this year, and the smallness of the crop was usually in proportion to the degree of neglect in which the orchards were growing. I have asked a number of the successful growers, whose orchards I have inspected, to prepare me a statement of their methods, and their accounts are here given. Several correspondents also report good crops of apples this year, and all of them attribute their success to careful treatment either of tillage, fertilizing or spraying. Amongst these are E. W. Catchpole, North Rose, Wayne Co.; Lyell Hill, Morton, Orleans Co.; J. Van Vorheis, Fisher's, Monroe Co.; J. B. Collamer, North Parma, Monroe Co.

T. G. Yeomans & Sons, Walworth, Wayne Co. (*see cut on page* 65).

We give the following statement of our experiments in spraying our apple orchards the past season.

This being the first season in which we have sprayed our apples with Bordeaux mixture, we feel reluctant to say too much in its favor till we have had more experience, except to say we are so well satisfied with the results that we shall repeat the same next year more extensively. We have about one hundred and thirty acres of apple orchards, which have been planted from thirty to forty-eight years, and which are nearly all Baldwins. Our spraying tanks hold about three hundred gallons and they are made like a thresher tank. The men who spray, stand on a platform on the rear end of the tank, about nine feet from the ground. This platform is made to project about one foot beyond the outside of the tank on each side, thus enabling the men to stand outside of the tank proper, and allowing them more room in which to work. A strong rail on the four sides of the platform prevents the men who spray from falling off the platform, and allows them to spray more securely and with less fear of being thrown off by the moving of the team. Each man has about twenty two feet of hose, the upper part of which is tied to a light pole twelve feet long to elevate the nozzle. The driver pumps, and the two men on the platform direct the spray, the three men alternating work. A small boy on the tank agitates the water with a hoe through the open trap in the top of tank, when the team is standing still, closing the trap when the team is in motion, to prevent slopping. We shall endeavor, however, to devise some automatic agitator, for the purpose of saving expense; and we shall expect, of course, to modify our outfit from year to year, as experience and the progress of invention seem to warrant. We used a Gould's double-spray pump, No. 905, and a Nixon nozzle, No. 3 cylinder with a No. 2 bottom, for all large apple trees, which gives the nearest approach to a perfect mist which we have been able to throw into the tops of our apple trees. We use thirty-two pounds of sulphate of copper to a tank, using the yellow prussiate of potash test for the quantity of lime, and always using two pounds of London purple per tank. The sulphate of copper we dissolve in suspension, in quantity, so that each gallon contains two pounds of the copper. We would advise that experiments be made to ascertain if enough more lime should not be added, after the potash test, to neutralize the acid in the London purple, the same as is done when it is used without the Bordeaux.

Plot A. — Sprayed twice before and twice after blossoming, viz.: April 26th and May 3d, (blossomed May 6th to 8th); May 22d, and June 4. This plot had a full crop of nice apples, several large limbs breaking from the weight of the apples. All Baldwins.

Plot B.— Sprayed twice before and once after blossoming, April 27th, May 5th, and 30th. One outside row not sprayed and had but few apples; the balance had a full crop of choice apples. All Baldwins.

Plot C.— Sprayed once before and twice after blossoming, viz.: April 30th, May 22d, and (because of rain) May 30th to June 4th: This plot had about a half crop of very nice apples — Baldwins and Greenings. An outside row of this plot, which was not sprayed, did not have a peck of fruit per tree.

Plot D.— Sprayed once before and once after blossoming, viz.: April 27th and May 30th. Result, half to two-thirds of a crop of Baldwins.

Plot E.—Thirty-five acres of Baldwins, blossomed as full as the others, but was not sprayed with Bordeaux. Result, a very light crop and foilage very badly injured by scab.

We are not prepared to advance the opinion that a crop can always be secured by spraying, nor that a crop cannot be grown without, for there are too many exceptions to attempt to establish any such rule. We are inclined to the opinion that we have not fully realized the importance of *early* spraying, and are convinced that very few persons spray *thoroughly.*

Whenever we have a period of long continued wet weather about the time the apples are setting, we have noticed that there is a very general complaint that "apples are not setting well," "apples are falling off badly," "my apples blossomed and set full, but we had twenty-one days of continuous rain and they all dropped off." Now, during that twenty-one days was the most favorable time possible for the growth of fungi. Did it not attack and destroy the fruit and cause it to drop? The damper and more rainy the weather in May and early June, the more urgent the necessity for spraying. We sprayed many days in a fine drizzling rain the past season.

No other persons in this vicinity sprayed at all with Bordeaux, and we have no knowledge of any orchard in this vicinity which has half a crop; many have very much less.

We keep our orchards in clean culture.

L. J. Yeomans

W. T. Mann, Barkers, Niagara Co. (see frontispiece).

My orchard was planted about 1870 to 1873, and contains eighty-eight trees, eighty-five of which are bearing. As the distance between them is only twenty-five by thirty feet the orchard occupies a little less than one and one-half acres. The soil varies from a clay loam to a sandy loam with a clay subsoil, and has sufficient irregularity of surface to afford good surface drainage. For perhaps ten or twelve years the young orchard was planted with hoed crops, and was then seeded and used for a number of years as a meadow. During the past three or four years it has been plowed and cultivated without cropping. All these years it has been occasionally fertilized with light dressings of barnyard manure.

Since 1889 it has been sprayed annually with an insecticide, and since 1891 with a fungicide. With this treatment it has produced fair crops annually for several years.

During the past season it has been kept well cultivated, first by a shallow plowing and later by frequent working with a spring-tooth harrow until the burdened branches prevented further passage. Early last summer the orchard was fertilized with an application of 200 lbs. of sulphate of potash and 400 lbs. of fine ground bone per acre, sowed with a grain drill. I find by my records that the orchard was first sprayed May 5th with the Bordeaux mixture and Paris green. At that time an occasional King blossom was open. May 12th the orchard was in full bloom. May 15th "heavy frost, crust frozen on the surface of the soil." May 19th the bloom had mostly fallen, and three weeks of rainy weather began. The 25th scab spots began to show on the foliage, though none was then visible on the fruit. May 31st sprayed the orchard the second time. This spraying was greatly delayed by the heavy and long continued rains. June 9th sprayed the orchard the third time. Under date of June 18th I find this statement in my notes: "Corner orchard full crop, but many one-sided because of the scab."

The mixture used in all of our sprayings in this orchard was prepared by adding ten pounds of sulphate of copper, in solution in water to a hundred-gallon tank, then adding milk of lime until the test of ferrocyanide of potassium was satisfied, and then one-half pound of Paris green was added, after which the tank was filled with water. We used a power pump with two nozzles, a Vermorel for the lower branches, and a McGowen for the tops. After applying the spray to each side of each row, we crossed the rows. In this way we endeavored to reach all parts of the trees, but in this effort we were disappointed, as a careful examination just before the picking season showed. At that time many of the trees bore but little fruit in the interior, while the outer branches which received the spray, were certainly overloaded. The results have satisfied me that thorough work can be accomplished only with a hand pump.

As to the results for this season, I present the following table. It should be stated, however, that it was the off or non-bearing year for the Cranberry Pippin, and many of the Greenings, and the price quoted is simply the average price paid here in our local market for good fruit:

Number of trees.	VARIETY.	Number of barrels.	Value at market price.
32	Baldwin	60	$90 00
23	Greening	32	48 00
16	King	31	46 50
10	Cranberry Pippin	8	12 00
2	Northern Spy	7	10 50
1	Fallawater	1	1 50
1	Early Harvest	1	1 50
85		140	$210 00
	Culls and windfalls, 99 bushels	....	19 80
			$229 80

The quality of this fruit is especially worthy of mention. In the case of the Baldwins a record was kept of the quantity of culls obtained from picked fruit. In one lot of nineteen barrels of first grade fruit, two bushel crates held all the culls. In case of another lot of fifteen barrels, one bushel crate held all the culls, and in the whole lot there were but eight bushels. In order to show the quality of the first grade fruit, I submit a copy of the statement of the buyer:

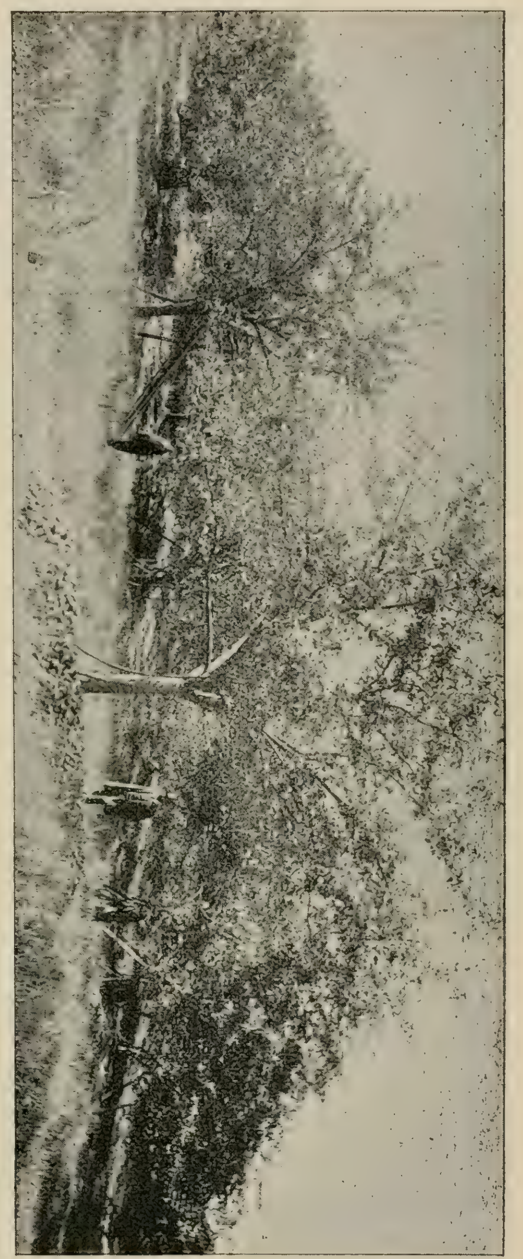
> "DEAR SIR: We are pleased to state that the Baldwin apples which we purchased from you and which you stated were from a well-sprayed orchard were the finest lot which we have seen this year. We noticed no wormy specimen, and but comparatively little injury from the scab.
>
> "E. L. ELLIS."

Now while this crop may not be remarkable for yield considering the amount of land, or number of trees, still, when we consider the size of the trees, the general failure of apples in this section, (the crop of the county being estimated at only twenty per cent.) and the quality of the fruit, the result is certainly very satisfactory.

W. T. Mann

H. L. Brown, Carlton, Orleans Co.

As near as I can get at it my orchard is about 30 years old. It contains 146 trees. We barreled 898 bbls. from the orchard this



8. Saved by spraying. The picture shows the props which were used to hold up the trees. H. L. Brown.

year, 749 firsts and 149 seconds. I have had the management of the orchard ever since 1889. That spring it was top dressed with yard manure and pastured to sheep. We got no apples. In 1890 pastured again, and no apples. In 1891 pastured and picked 100 bbls. In 1892 pastured and picked about 75 bbls. of poor apples. It was top dressed in 1893 with yard manure, and pastured. We shook off about 200 bushels of drying apples. In the late fall of 1893 and the winter of 1894, we gave the orchard a heavy dressing of stable manure of the best quality. In the spring of 1894, we gave the orchard a very severe pruning and began spraying. In this work we followed the directions of Cornell Bulletin No. 60. We used

Bordeaux exclusively. I can not give the exact date of each spraying. The first one was made early in May, before any leaves started. The next one came just as the buds began to show a little red color. The third one was made after the blossoms had fallen and fruit set. Part of the orchard was sprayed the fourth time, the very last of June, and I could see a marked difference in favor of four sprayings.

The general result has been everything I could ask. I sold apples for \$2.12½ and our neighbors could get only \$1.50 to \$1.75.

H. L. Brown

G. H. Bradley & Son, Lake Road, Niagara Co.

Our Duchess of Oldenburg orchard is 17 years old and has 375 trees which produced this year 900 barrels firsts and windfalls, which netted us \$2,100. We sprayed three times with Paris green. The orchard has been cultivated and fertilized with stable manure heavily for the last four or five years. There were almost no No. 2 apples. We picked 200 barrels at one picking and had only 3 barrels of No. 2.

Our Twenty Ounce orchard yielded at the rate of \$400 per acre, treatment same as Duchess, except that it was sprayed seven times with Paris green and Bordeaux mixture. Baldwins and Kings yielded at the rate of \$150 per acre, and the quality was No. 1. They were also sprayed and manured.

Duchess sold for \$2.75 per barrel.

Twenty Ounce sold for \$2.35 per barrel.

Baldwins and Kings sold for \$2.00 per barrel.

G. H. Bradley + Son

*Albert Wood, Carlton, Orleans Co.** (*See frontispiece.*)

My orchard covers about twenty-five acres and was set in the spring of 1860. The land is moderately rolling, descending toward the north, and is well underdrained with stone trenches. The

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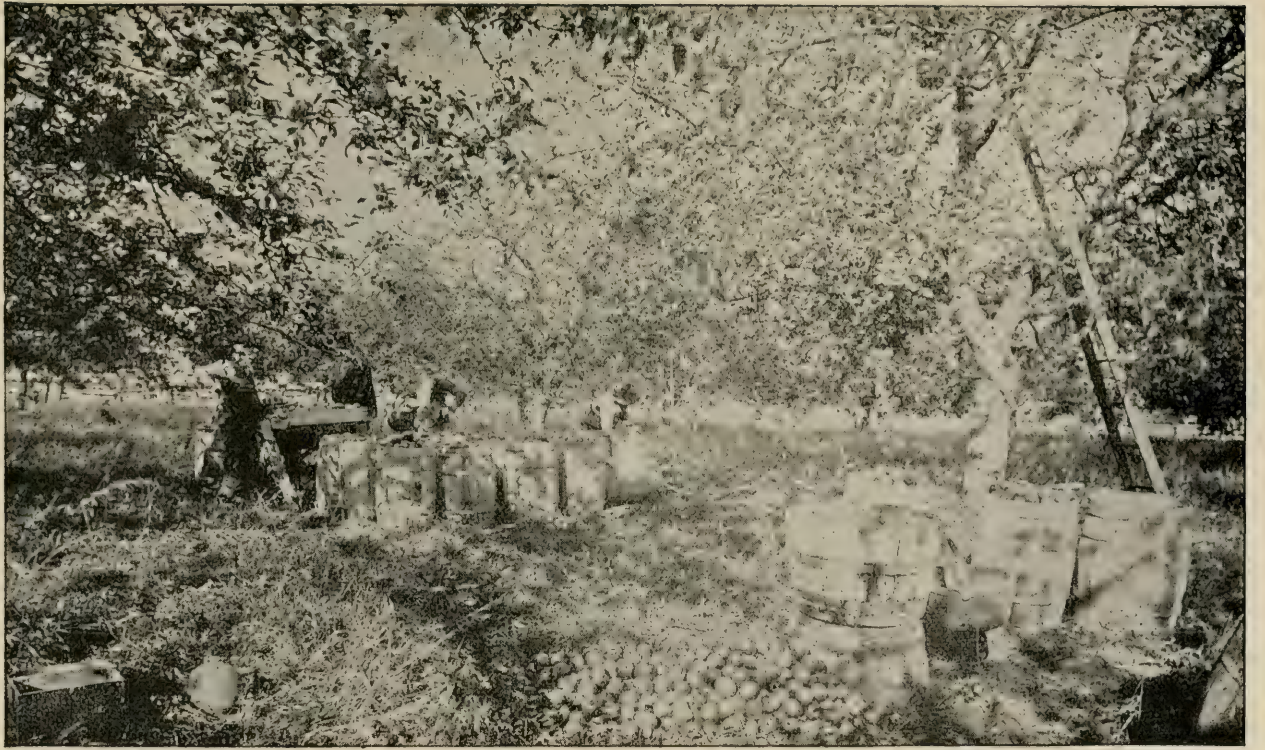
* Mr. Wood's account was also presented to the Western New York Horticultural Society, January 23, 1895, but it was first prepared for this bulletin.



9. The reward of tillage, feeding and spraying. G. H. Bradley & Son. (See page 74.)

soil is deep, gravelly loam, and the orchard bore fairly well up to eight years ago. Six years ago I became convinced that, like all orchards of early setting, the trees were altogether too thick; they interlocked, and the red apples, such as Baldwins, were, as you might say, growing white from lack of sun and air; the ground was covered with moss, and, as well as the trees, had become unproductive. I had one-half of the orchard cut down diagonally, leaving the remaining trees standing in diamond order, twenty-four trees to the acre. As a result of this thinning out, the ground lost its sourness and became covered with grass — in fact the change was as great as in a cup of black coffee after receiving cream and sugar. I wish to say, for the benefit of my brother fruit growers, that the butts of those trees were sold for fifty-five dollars per thousand to Henry Disston & Sons, saw manufacturers of Philadelphia, yielding me about six hundred dollars. But all this thinning out, with good culture and heavy manuring added, did not rid this orchard of the apple-scab fungus. The foliage was rusty and the apples scabby every year, though there was a fairly good yield of inferior fruit. In January, 1893, according to my custom, I visited the Western New York Horticultural Society, and made myself thoroughly acquainted with the scab fungus through information received, and carefully noting the valuable suggestions in our excellent Experiment Station bulletins. In the following spring, I selected two Baldwin trees which bloomed fairly well, and gave them three thorough sprayings with the Bordeaux mixture. These two trees gave me a heavy crop of first class apples; while the fruit in the balance of the orchard was so scabby that the bulk of it was sent to the dry house, and those I packed were by no means of the first quality. This experiment thoroughly converted me to the importance of spraying orchards for profit; and in the spring of 1894 I set to work with all the force and confidence which I every year expend in raising fifty to seventy-acres of beans. I will now give the results of seven tests of spraying.

First Test.—On April 23, 1894, I commenced with the Bordeaux mixture on my apple orchard (twenty pounds sulphate of copper and four pails of milk of lime to one hundred and fifty gallons of water) just as the buds began to swell. Greening, Baldwin, King, Twenty Ounce, Talman Sweet, Strawberry—in fact all my varieties were treated in the same manner and at the same time. May 1st, I began a second spraying, using the same formula with the exception of one pound of Paris green added. The buds were at this time about as large as a robin's egg. Before this spraying was finished, the buds opened somewhat, showing the flower. Following this spraying, we had a very heavy rainfall — over five inches on the level — but the lime and the sulphate of copper still adhered to the foliage and was plainly visible, which gave me great confidence that after the mixture was once set it would remain and do its work. The third spraying was done with the same mixture as the second, and when the apples were on an average about one half inch in diameter, although some were larger. They had a healthy stem and satisfied me they had come to stay; there were fourteen large Baldwin trees not sprayed, and these were dropping fruit, and the stems of what remained on the trees were turning yellow and ready to fall.

Second Test.—My pear orchard was treated the same way as my apple orchard. In both orchards the sprayed trees were heavily loaded. Indeed, there was hardly a tree in either orchard that had not one or more limbs broken by the weight of the fruit. The foliage was dark, rich, rank and heavy, a wonder to the whole neighborhood, especially the perfect fruit growing on the inside of the trees on the small fruit spurs. In fact, I made a standing offer to my city friends and to my neighbors, that if they could find a wormy or a scabby apple on any tree that had been treated, I would make them a present of their winter supply of fruit. When we picked the crop, the fourteen trees not treated had no apples on the inside; the foliage was rusty and dropping; there were some apples on the top branches, but I gathered only thirty-five barrels from fourteen trees when I ought to have had one hundred and thirty-five. The picking began October 1st. The apples were placed in packages and remained thirty-four days after being barreled. The buyers, as all know, require close packing; and I found the thirty-five barrels from fourteen unsprayed trees had shrunk five barrels, while those from the sprayed trees (two thousand four hundred barrels) had not shrunk five in two thousand. The crop was sold for three shillings per barrel more than the average market price. The two trees sprayed in 1893, and again this year, also bore a few apples, but every apple was perfect, showing that by a proper use of the Bordeaux mixture we can raise apples in the off year.

Third Test.—I had one Strawberry tree from which I had not had a perfect apple in nine years. I sprayed it. This was its off year (1894) but every apple was large and perfect. The same can be said of the old-fashioned Holland Pippin.

Fourth Test.—One tree of my Kings was left untreated. The apples were worthless, while those treated gave results equal to the best, though a little undersized, owing to the heavy crop.

Fifth Test.—One tree of Twenty Ounce was left untreated. The apples were covered with scabs and checks, making them entirely worthless, while those on the treated trees were extra large, and smooth as glass.

Sixth Test.—One tree of Roxbury Russet was left unsprayed. I can safely say that three-fourths of the apples were fit only for cider, the balance only passable. The Russets from the treated trees were not so smooth as the other varieties. I find them to be more susceptible to the scab than other varieties, and have concluded they should be sprayed five times.

Seventh Test.—I have one old standard pear tree, 25 feet high, of the old White Doyenne or Virgalieu variety. I have not had a single perfect pear from this tree in twenty-five years. This year, after being treated according to the Cornell spray calendar, it was loaded, and there was not one imperfect pear on the tree. I called the especial attention of Professor Bailey to that tree, and he conceded that he could not find a single imperfect specimen upon it. Over fifty other fruit growers who visited me during the season gave the same testimony.

I can safely say that in size, quantity, quality and keeping properties, these tests show at least ninety per cent. in favor of spraying. In one block of twenty-five hundred dwarf Duchess pear trees, set four years ago, I sprayed twice, leaving one row. In riding along the road during the growing season any one could see a difference in the foliage. That on the unsprayed trees fell early, while that on the treated trees held on till after the second hard freeze; and the trees showed a growth from a fourth to a third more than the unsprayed.

In another block of about the same number, set at the same time (principally Kieffer, standard and dwarf Anjou) treated in the same manner, there were similar results. The same can be said of a block of Orange quince, set at the same time. In fact, all varieties of fruit gave marked results. No description can do injustice to the effect of spraying my cherries and plums. The latter astonished all who saw them. The foliage on my Fay currant bushes was a thing of beauty. We gathered fruit hidden under the rank growth, twenty days after the unsprayed bushes were entirely bare. I wish to say to the fruit growers of western New York, that we can raise fruit as in the old times. Of course, in case of storms or heavy cold rains at the time when the flower is being fertilized, we are liable to loss, as the rains wash off the pollen. My apple orchard is now in grass, pastured very close with sheep, which I consider the right kind of treatment, to prevent the grass from growing so high as to act as a pump on the soil. The Bordeaux mixture must be applied in the form of a vapor,* and the proper appliances must be employed, proper nozzles and proper spraying machines, to insure success. For a large orchard the pump should be strong enough to carry two leads of hose with four nozzles, that is, two on each lead of hose with Y attachment. Three of my neighbors, Harry Brown, (see page 74) George D. Simpson and Frank Cohoon, can furnish equally strong testimony regarding the benefits of spraying their orchards. The quantity and quality of their fruit and prices received were far in advance of those who failed to treat their orchards.

Albert Wood

A Michigan Experiment in Renovating an Old Orchard.

The first investigation which I made of the reasons for the failure of the apple crop was inaugurated in 1885 at the Michigan Agricultural College. At this time the Paris green spray was in its experimental stage and Bordeaux mixture had not been used upon orchards. The following account was published at the time,† but as it was before the establishment of the general experiment stations, the experiment attracted little attention. There is nothing unusual in the experiment, and it is inserted here chiefly for the purpose of illustrating the fact that treatment for the renovating of an old orchard must be continued three or four years before great increase in the crop is to be expected.

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* That is, a fine strong spray. Mr. Wood used the McGowan nozzle. L. H. B.

† Bull. 31, Agric. College of Mich. 82 (1887).

"The college apple orchard, originally comprising about nine acres, was set in 1858. The original plantings were mostly Northern Spy, Baldwin, Talman Sweet and Seek-no-further. The soil is a strong sandy loam, in some parts inclining to be cold and wet. The orchard has received various treatments. For nearly ten years, beginning about 1873, careful and valuable experiments in culture were carried on by Dr. W. J. Beal. In recent years the orchard has received less attention, being allowed to stand in sod. It has borne very few good crops, even from the first. In 1885, when the immediate control of the orchard passed into the hands of the writer, the trees presented a discouraging appearance. The previous hard winter had destroyed many of the largest trees on the lower land. Most of these trees were Baldwins, Greenings and Fall Jennettings. In fact, there is only one Baldwin left in the orchard and but two or three Greenings and Jennettings, and all are feeble. Many or all of these trees had been injured by a hard winter some ten or twelve years before. The remaining trees of the orchard apparently from neglect in culture, were feeble during the year, the leaves presenting a yellow and sickly appearance. Many of them appeared to be dying. All the trees were very much stunted, there not being enough last year's wood on most of them to furnish even a few good scions. Many of the main limbs had died back from the ends and the dead portions were conspicuous in every direction. The trunks were often mossy and rough. The tops for the most part very thick and low, so that no attempt at thorough culture could be made. Most of the orchard lay in a dense June grass turf. In short, the orchard was in so poor condition that several careful farmers recommended that it be cut down.

"The first work of renovation was to prune the trees. This was done vigorously in May, 1885, the tops being made high enough in every instance to allow the passage of a horse in harness. All limbs, irrespective of size, which would interfere seriously with plowing and cultivating were removed. At the same time the tops of the trees were thinned considerably, though not to such an extent as to allow the sun to beat continuously upon the main branches. The trunks and main limbs, so far as a man could reach, were scraped, all the loose bark and moss being removed. This scraping was performed solely for the purpose of making the trees look better. * * * As soon as the pruning was accomplished and the great quantity of brush removed, the ground was plowed, and plowed as deeply as possible. To be sure, roots were broken, but this did no harm. The ground was cultivated at intervals with the spring-tooth harrow, and in August a second plowing, in the opposite direction, was made. No crops were planted. There was no effect produced upon the trees that year. The season's growth, if any, was well under way when the first plowing was made. The leaves continued yellow, and fell very early, as usual.

"In 1886 the same treatment was repeated. Nearly as much pruning was done as in the previous year; this time, of course, entirely in the tops of the trees. Care was exercised, however, not to prune the tops so thin that the large limbs would be injured by the sun. The trees early showed signs of improvement. Although the summer was dry, the growth on all the trees was good, and the leaves assumed a dark, vigorous color, and remained very late upon the trees. So marked was the improvement in the orchard that it was a subject of common remark. A fair crop of apples, some 300 bushels, was also gathered.

"In the spring of 1887 the orchard was again plowed, deeply as always before, and the sod was removed from all the trees by hand. The tops are now so high that the plow turned over nearly all the sod. The ground was now in good heart. The trees set very full of fruit and no pruning was attempted. Although the trees have borne a heavy crop, and the season has been one of almost unprecedented drouth, the growth has been heavy. The bearing trees are 140 in number, of which less than 100 — all Northern Spy — are a prolific variety and produced apples which find a demand in market. There are a number of Sweet Romanites and others which can not be expected to return a profitable crop. The sales for the year have been as follows:

274 barrels No. 1 (822 bushels) at $1.35	$369 90
100 barrels No. 2 (300 bushels) at 75 cents	75 00
60 bushels at 25 cents	15 00
100 bushels at 30 cents	30 00
220 bushels made into cider at 20 cents	44 00
300 bushels cider apples at 5 cents	15 00
1802 bushels	$548 90

"The reason for the great proportion of cider apples is the heavy crop and the drouth, rendering it impossible for all the fruit to mature. Thinning would probably have paid. The crop was remarkably free from worms. Old apple buyers declared that they had never seen so few wormy apples in a crop. This freedom from insects was due to sprayings of Paris green. * * * We used a half-pound of Paris green to a kerosene barrel of water. In one instance we used three-fourths of a pound, but the liquid injured the foliage.

"Permanent sod (without fertilizing) is an injury to the orchard. This has been proved in the experience of nearly every successful orchardist. It is forcibly illustrated in the instance of the old College orchard. In the earlier experiments conducted by Dr. Beal, the same fact was emphasized. For some years he kept a part of the trees in sod, others were cultivated thoroughly, while still others were cultivated at varying distances from the body of the tree. Even as early as 1874 he found that 'trees in grass made less growth, looked yellow in foliage, and bore smaller fruit and apparently less of it.' In 1875 he observed that 'the evidences looked more and more strongly every year against the propriety of leaving trees, in our section, in grass. They have stood the severe winters no better; they have borne no better; the apples are smaller; the trees grow more slowly; a greater proportion of trees have died than of those cultivated each year. So marked have been the results that we have plowed up about half that part of the orchard which was left in grass.'"

L. H. Bailey

SUMMARY.

Till.
Feed.
Prune.
Spray.

POMOLOGICAL PUBLICATIONS OF CORNELL UNIVERSITY EXPERIMENT STATION.

Those bulletins which are out of print are marked with an asterisk. Articles which are published along with other matter, in miscellaneous bulletins, are placed in parenthesis.

*Bulletin 3 (1888). (On the Destruction of the Plum Curculio by Poisons.)
*—— 9 (1889). Windbreaks in their Relation to Fruit Growing.
*——14 (1889). Strawberry Leaf Blight.
*——15 (1889). (Anthracnose of Currants. Leaf Blight of Quince and Pear. The Apple-Tree Tent Caterpillar. The Crandall Currant.)
*——18 (1890). Experiences in Spraying.
*——19 (1890). Report upon the Condition of Fruit Growing in western New York.
*——23 (1890). Insects Injurious to Fruit.
*——25 (1890). (The Peach Yellows.)
*——34 (1891). Dewberries.
*——35 (1891). Combination of Fungicides and Insecticides.
——38 (1892). The Cultivated Native Plums and Cherries.
*——44 (1892). Pear-Tree Psylla.
——46 (1892). Mulberries.
*——48 (1892). Spraying Apple Orchards in a Wet Season.
——49 (1892). (The Black Peach Aphis. Fertilizers for Grape Cuttings. Black-Knot of the Plum and Cherry. The Vetch or Tare as an Orchard Plant.)
*——50 (1893). The Bud Moth.
*——51 (1893). Four New Types of Fruits—Prunus Simonii. Wineberry. Crandall Currant. Dwarf Juneberry.
*——57 (1893). Raspberries and Blackberries.
——58 (1893). The Four-lined Leaf Bug.
——59 (1893). Does Mulching Retard the Maturity of Fruits?
*——60 (1893). The Spraying of Orchards.
——61 (1893). (Œdema of Apple Trees. The Pear-Leaf Blister. Orchard Covers,—Vetch, Cow Peas, Peas, etc. Labels.)
——62 (1894). The Japanese Plums in North America.
——69 (1894). Hints on the Planting of Orchards.
——70 (1894). The Native Dwarf Cherries.
——71 (1894). Apricot Growing in western New York.
——72 (1894). The Cultivation of Orchards.
——73 (1894). Leaf Curl and Plum Pockets.
——74 (1894). Impressions of the Peach Industry of western New York.
——75 (1894). Peach Yellows.
——76 (1894). Some Grape Troubles in western New York.
——77 (1894). The Grafting of Grapes.
——79 (1894). Varieties and Leaf Blight of the Strawberry.
——80 (1894). The Quince in western New York.
——81 (1894). Black Knot of Plums and Cherries, and Methods of Treatment.
——83 (1894). A Plum Scale in western New York.

Cornell University—Agricultural Experiment Station.

HORTICULTURAL DIVISION.

February, 1895.

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SPRAY CALENDAR.

By E. G. LODEMAN.

SPRAY CALENDAR.

In the preparation of this calendar the most important points regarding sprays have been selected and arranged in such a manner that the grower can see at a glance what to apply and when to make the applications. The more important insect and fungous enemies are also mentioned, so that a fairly clear understanding of the work can be obtained by examining the table. When making the applications advised, other enemies than those mentioned are also kept under control, for only the most serious ones could be named in so brief an outline. The directions given have been carefully compiled from the latest results obtained by leading horticulturists and entomologists, and they may be followed with safety.

Notice.— In this calendar it will be seen that some applications are italicised, and these are the ones which are *most important.* The number of applications given in each case has particular reference to localities in which fungous and insect enemies are most abundant. If your crops are not troubled when some applications are advised, it is unnecessary to make any. It should be remembered that in all cases success is dependent upon the exercise of proper judgment in making applications. Know the enemy to be destroyed; know the remedies that are most effective; and finally, apply them at the proper season. Be *prompt*, *thorough*, and *persistent.* Knowledge and good judgment are more necessary to success than any definite rules which can be laid down. Black knots on plums or cherries should be cut out and burned as soon as discovered. For alphides or plant lice use kerosene emulsion on all plants.

SPRAY CALENDAR.

PLANT.	First application.	Second application.	Third application.	Fourth application.	Fifth application.	Sixth application.
APPLE. *(Scab, codlin moth, bud moth.)*	When buds are swelling, copper sulphate solution.	*4 to 7 days before blossoms open, Bordeaux. For bud moth, Arsenites when leaf buds open.*	*When blossoms have fallen, Bordeaux and Arsenites.*	*8 to 12 days later, Bordeaux and Arsenites.*	10 to 14 days later, Bordeaux.	10 to 14 days later, Bordeaux.
BEAN. *(Anthracnose.)*	*When third leaf expands, Bordeaux.*	10 *days later, Bordeaux.*	14 days later, Bordeaux.	14 days later, Bordeaux.		
CABBAGE. *(Worms, aphis,)*	*When worms or aphis are first seen. Kerosene emulsion.*	7 to 10 days later, if not heading, renew emulsion. Hellebore.	*7 to 10 days later, if heading, hot water 130° F.* Hellebore.	Repeat third in 10 to 14 days if necessary.	(When plants are small Arsenites may be used to check worms.)	
CARNATION. *(Rust and other fungous diseases, red spider.)*	*When rust is first noticed, Bordeaux. Kerosene emulsion when red spider is first seen.*	*For rust repeat first in 10 to 14 days. For red spider repeat in 3 to 4 days.*	*Repeat second* using the Ammoniacal carbonate of copper if plants are in bloom.	Repeat second as before if necessary.		
CHERRY. *(Rot, aphis, slug.)*	As buds are breaking, Bordeaux; when aphis appears, Kerosene emulsion.	When fruit has set, Bordeaux. If slugs appear, dust leaves with air-slaked lime. Hellebore.	10 to 14 days if rot appears, Bordeaux.	10 to 14 days later, Ammoniacal copper carbonate.		

SPRAY CALENDAR — (*Continued*).

PLANT.	First application.	Second application.	Third application.	Fourth application.	Fifth application.	Sixth application.
CURRANT. (*Mildew, worms.*)	*At first sign of worms, Arsenites.*	10 days later, Hellebore. *If leaves mildew, Bordeaux.*	If worms persist, Hellebore.			
GOOSEBERRY. (*Mildew, worms.*)	*When leaves expand Bordeaux.* For worms as above.	*10 to 14 days later, Bordeaux.* For worms as above.	*10 to 14 days later, Ammoniacal copper carbonate.* For worms as above.	*10 to 14 days later, repeat third.*		
GRAPE. (*Fungous diseases, Flea-beetle.*)	In Spring when buds swell, copper sulphate solution. *Paris green for flea beetle.*	*When leaves are 1 to 1 1-2 inches in diameter, Bordeaux. Paris green for larvæ of flea beetle.*	*When flowers have fallen, Bordeaux. Paris green as before.*	*10 to 14 days later. Bordeaux.*	10 to 14 days later if any disease appears, Bordeaux.	10 to 14 days, Ammoniacal copper carbonate. Make later applications of this if necessary.
NURSERY STOCK. (*Fungous diseases.*)	*When first leaves appear, Bordeaux.*	*10 to 14 days, repeat first.*	10 to 14 days, repeat first.	10 to 14 days, repeat first.	10 to 14 days, repeat first.	10 to 14 days, repeat first.
PEACH, NECTARINE, APRICOT. (*Rot, mildew.*)	*Before buds swell, copper sulphate solution.*	Before flowers open, Bordeaux.	*When fruit has set, Bordeaux.*	*When fruit is nearly grown, Ammoniacal copper carbonate.*	*5 to 10 days later repeat fourth.*	5 to 10 days later repeat fourth if necessary.

SPRAY CALENDAR — (*Continued*).

PLANT.	First application.	Second application.	Third application.	Fourth application.	Fifth application.	Sixth application.
PEAR. (*Leaf blight, scab, psylla, codlin moth.*)	As buds are swelling, copper, sulphate solution.	*Just before blossoms open, Bordeaux. Kerosene emulsion when leaves open for psylla.*	*After blossoms have fallen, Bordeaux and Arsenites. Kerosene emulsion if necessary.*	8–12 *days later repeat third.*	10–14 days later, Bordeaux. Kerosene emulsion applied forcibly for psylla.	10–14 days later, repeat fifth if necessary.
PLUM. (*Fungous diseases, curculio.*)	*During first warm days of early spring, Bordeaux for black knot. When leaves are off in the fall, Kerosene emulsion for plum scale.*	*When buds are swelling, Bordeaux for black knot and other fungous diseases.* During mid-winter, Kerosene emulsion for plum scale.	*When blossoms have fallen, Bordeaux. Begin to jar trees for curculio. Before buds start in spring. Kerosene emulsion for plum scale.*	10–14 *days later, Bordeaux. Jar trees for curculio every 2–4 days.* For San José scale. Kerosene emulsion when young appear in spring and summer.	10–20 *days later, Bordeaux for black knot. Jar trees for curculio.* When young plum scale insects first appear in summer, Kerosene emulsion.	10–20 *days later, Bordeaux for black knot. Later applications may be necessary to prevent leaf spot and fruit rot, use Ammonical copper carbonate.*
POTATO. (*Scab, blight, beetles.*)	*Soak seed for scab in corrosive sublimate solution (2 oz. to 16 gals. water) for 90 minutes.*	*When beetles first appear, Arsenites.*	*When vines are two-thirds grown, Bordeaux; Arsenites for beetles if necessary.*	10–15 days later, repeat third.	10–15 days later, Bordeaux if necessary.	
QUINCES. (*Leaf and fruit spots.*)	When blossom buds appear, Bordeaux.	When fruit has set, Bordeaux and Arsenites.	10–20 *days later, Bordeaux.*	10–20 *days later, Bordeaux.*	10–20 *days later, Bordeaux.*	
RASPBERRY .... BLACKBERRY ... } .... DEWBERRY ..... (*Anthracnose rust.*)	Before buds break, copper sulphate solution. Cut out badly diseased canes.	During summer, if rust appears on leaves, Bordeaux.	Repeat second if necessary.	*(Orange or red rust is treated best by destroying entirely the affected plants.)*		

SPRAY CALENDAR — (*Concluded*).

PLANT.	First application.	Second application.	Third application.	Fourth application.	Fifth application.	Sixth application.
ROSE. (*Mildew, black spot, red spider, aphis*).	For mildew. *Keep heating pipes painted with equal parts lime and sulphur mixed with water to form a thin paste.*	For black spot. *Spray plants once a week with Ammoniacal copper carbonate, using fine spray.*	For red spider. *Spray plants twice a week with Kerosene emulsion. Apply to under side of foliage.*	For aphis. *Spray affected parts with Kerosene emulsion when necessary.*		(Kerosene emulsion must be used very dilute, as rose foliage is easily injured by it.)
STRAWBERRY. (*Rust.*)	*As first fruits are setting, Bordeaux.*	As first fruits are ripening, Ammoniacal copper carbonate.	*When last fruits are harvested, Bordeaux.*	Repeat third if foliage rusts.	Repeat third if necessary.	(Young plants not in bearing may be treated throughout the fruiting season.)
TOMATO. (*Rot, blight.*)	At first appearance of blight or rot under glass or out of doors, Bordeaux.	Repeat first if diseases are not checked.	Repeat first when necessary.			
VIOLET. (*Blight, red spider.*)	*When blight is first seen in summer, Bordeaux. Kerosene emulsion for insects when necessary.*	*Repeat first in* 10-20 *days for blight.*	Repeat first in 10-20 days for blight.	Repeat first if necessary.	(Bordeaux mixture has been treated for violet diseases only to a limited extent.)	(Kerosene emulsion must be used very dilute, as violet foliage is easily injured by it.)

FORMULAS.

BORDEAUX MIXTURE.

Copper sulphate	6 pounds
Quicklime	4 "
Water	40-50 gallons

Dissolve the copper sulphate by putting it in a bag of coarse cloth and hanging this in a vessel holding at least 4 gallons, so that it is just covered by the water. Use an earthen or *wooden vessel.* Slake the lime in an equal amount of water. Then mix the two and add enough water to make 40 gallons. It is then ready for immediate use but will keep indefinitely. If the mixture is to be used on peach foliage it is advisable to add an extra pound of lime to the above formula. When applied to such plants as carnations or cabbages it will adhere better if about a pound of hard soap be dissolved in hot water and added to the mixture. For rots, moulds, mildews, and all fungous diseases.

AMMONIACAL COPPER CARBONATE.

Copper carbonate		1 ounce
Ammonia	1 volume 26° Beaumé. 7–8 volumes water	enough to dissolve the copper.
Water		9 gallons

The copper carbonate is best dissolved in large bottles, where it will keep indefinitely and it should be diluted with water as required. For the same purposes as Bordeaux mixture.

COPPER SULPHATE SOLUTION.

Copper sulphate	1 pound
Water	15 gallons

Dissolve the copper sulphate in water, when it is ready for use. *This should never be applied to foliage, but must be used before the buds break.* For peaches and nectarines use 25 gallons of water. For fungous diseases.

PARIS GREEN.

Paris green	1 pound
Water	200-300 gallons

If this mixture is to be used upon peach trees, 1 pound of quicklime should be added. Repeated applications will injure most foliage, unless lime is added. *Paris green and Bordeaux mixture can be applied together with perfect safety.* Use at the rate of 4 ounces of the arsenites to 50 gallons of the mixture. The action of neither is weakened, and the Paris green loses all caustic properties. For insects which chew.

LONDON PURPLE.

This is used in the same proportion as Paris green, but as it is more caustic it should be applied with two or three times its weight of lime, or with the Bordeaux mixture. The composition of London purple is exceedingly variable, and unless good reasons exist for supposing that it contains as much arsenic as Paris green, use the latter poison. Do not use London purple on peach or plum trees unless considerable lime is added. For insects which chew.

HELLEBORE.

Fresh white hellebore	1 ounce
Water	3 gallons

Apply when thoroughly mixed. This poison is not so energetic as the arsenites and may be used a short time before the sprayed portions are harvested. For insects which chew.

KEROSENE EMULSION.

Hard soap	½ pound
Boiling water	1 gallon
Kerosene	2 gallons

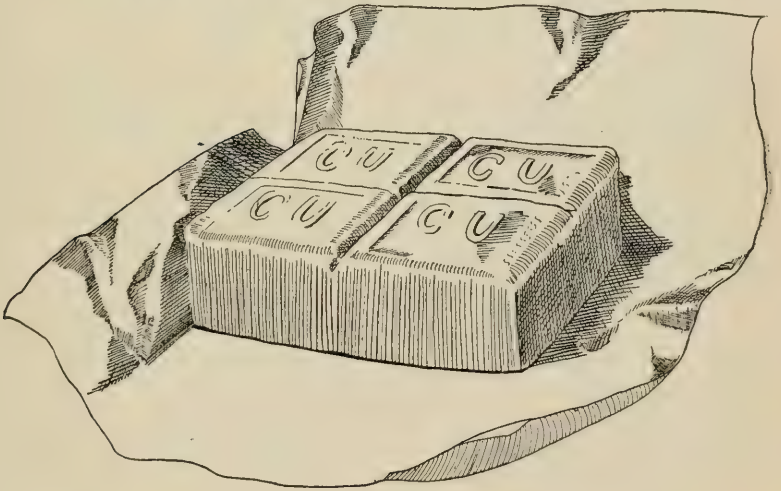
Dissolve the soap in the water, add the kerosene, and churn with a pump for 5-10 minutes. Dilute 10 to 25 times before applying. Use strong emulsion, diluted 4 times in winter, for all scale insects. For insects which suck, as plant lice, mealy bugs, red spider, thrips, bark lice or scale. Cabbage worms, currant worms and all insects which have soft bodies, can also be successfully treated.

BULLETIN 85—March, 1895.

Cornell University—Agricultural Experiment Station.

AGRICULTURAL DIVISION.

WHEY BUTTER.



By H. H. Wing.

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BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.
85. Whey Butter.

Whey Butter.

In the process of cheese making a small percentage of fat escapes in the whey. This fat is lost except in so far as it adds a slightly increased feeding value to the whey. From some hints that we had received from Dr. S. M. Babcock of the Wisconsin Agricultural Experiment Station, we were led to believe that this fat could be utilized in the form of commercial butter. Partly with the purpose of making some investigations into this matter and partly to afford our students addititional practice in running the separators we determined at the beginning of the Short Dairy Course term of 1895 to run the whey through the separators, and if possible to make butter of the fat that we were thus enabled to secure. Accordingly January 18, 1895, we began to run the whey from the cheese making regularly through the separators and we have been successful in securing a large proportion of the fat in the whey in the form of commercial butter of good quality. This butter has been scarcely, if any, inferior to that made from cream, separated from whole milk and it has been printed and sold in the same market with our best butter. The details of the various separations and churnings are shown in the table below.

This work has been done with the coöperation of Mr. W. W. Hall, Instructor in Cheese Making, and Mr. Jared VanWagenen, Jr., Instructor in Butter Making. The details of the work were almost entirely in their hands and to them most of the credit of the work is due.

It will be seen that upon the average we have been able to secure 2.57 pounds of butter from each 1000 pounds of whey and that the whey has contained upon the average .25 of 1 per cent. of fat, showing that we have recovered in the form of butter nearly all of the fat in the whey.

In only a few details does the manufacture of whey butter differ from ordinary butter making.

On account of the small percentage of fat in the whey it was found to be impracticable to secure at one separation a cream

Date.	Pounds whey.	Per cent. fat in whey.	Pounds cream.	Age of cream. Hours.	TEMP. CHURNED.		Time of churning. Min.	Weight of finished butter.	Pounds of butter per 1,000 lbs. of whey.
					Begin.	End.			
January 19	1,391	.30	14.5	20	50	54	30	4.18	3.01
January 21	1,523	.33	......	48	42	55	13	5.17	3.40
January 23	3,001	.26	37	24–48	52	......	20	7.72	2.57
January 24	1,505	.30	27	24	54	......	15	7.64	5.08
January 25	1,535	.27	28.5	24	51	58	11	5.00	3.26
January 26	1,497	.23	......	20	50	......	20	3.48	2.32
January 28	1,450	.30	16	48	44	62	4	3.66	2.52
January 29	1,530	.25	16	24	51	......	......	3.34	2.18
January 30	1,497	.22	......	24	56	66	4.5	3.12	2.08
January 31	1,455	.24	12.5	24	48	56	32	3.67	2.52
February 1	1,372	.21	12.5	24	48	......	15	3.02	2.20
February 2	1,401	.27	12	20	56	58	35	3.32	2.37
February 4	1,350	.25	......	3	49	......	......	2.50	1.85
February 5	1,383	.26	......	24	45	51	......	2.94	2.13
February 6	1,349	.22	21.25	20	50	54	116	3.00	2.22
February 7	1,387	.23	......	24	45	59	25	2.84	2.05
February 8	1,380	.22	......	24	......	......	......	2.52	1.83
February 12	1,445	.23	12	24	54	62	12	4.65	3.22
February 15	1,222	.21	......	48	......	......	......	2.27	1.86
February 16	1,340	.23	15	24	54	60	4	3.84	2.87
February 20	1,700	.21	......	24	......	......	......	4.71	2.77
Average	......	.25	......	......	......	......	......	......	2.57

thick enough for best results without churning it more or less in the separator. In order to overcome this the whey was put through the separator in the same way milk would have been and about one-tenth the whole bulk taken from the cream outlet. This was found to contain on the average from 2 per cent. to 5 per cent. of fat or to be of nearly the same fat content as ordinary milk. This so-called "first cream" was run through the separator a second time, and in this way the cream condensed to the proper consistency for churning. In running the Danish-Weston machine, this was not found to be necessary. The Danish-Weston machine is provided with a contrivance whereby the proportional flow from the skim milk and cream outlets can be controlled at will and in running the whey through this machine it was found entirely feasible to shut off the cream outlet entirely until a sufficient amount of cream had gathered in the center of the bowl, when by turning in the skim-milk point this cream could be thrown out, and after being so removed the skim-milk point could be thrown back again until a second portion of the cream had gathered in the center of the bowl. In this way we were enabled to get a clean separation and cream of good consistency in one operation.

In all of our experiments the whey was run through the separator immediately after it was drawn and before it had cooled down. It was at this stage, of course, slightly acid and the resulting cream was in good condition to churn at once after being reduced to the proper temperature. We have had no difficulty, however, so far as the flavor of the butter was concerned in holding the whey 24 or even 48 hours in some cases, but would strongly recommend that the whey cream be churned as soon as convenient after separation. In one case where it was attempted to hold the whey 48 hours before separating, the development of lactic acid went so far that the flavor of the butter was spoiled. The practical point seems to be that the whey should be separated at once and where possible the cream churned quickly, and preferably in any case the whey cream should not be held more than 24 hours.

The cream from the whey, containing as it does, very little casein, was very easily, quickly and completely churned at a low temperature. The most complete churning was obtained when the churn was started at a temperature from 48° F. to 54° F., the time required in most cases being less than 20 minutes.

In regard to the quality of butter; as before stated butter made from the whey has gone into the same market as the butter made in the ordinary way. Good judges who have seen the two kinds of butter side by side have been in some cases unable to detect which was made from whey and which from cream. In other cases slight inferiority in texture and flavor have been noticed in the whey butter. That it is possible to make butter of good commercial quality we have clearly shown. Whether or not it can be done at a profit, is the practical question for the ordinary factoryman.

In order to enable the ordinary factory to utilize the fat wasted in this way, it would be necessary to provide storage capacity for a large part of the whey produced in any given day, and a centrifugal separator, churn and butter worker. In cases where more than one vat of milk is made up, by so arranging the work that the whey would be drawn from the vats at different times, it would not be necessary to provide so much storage, for the separator could be started as soon as the first whey was drawn and much of the whey could be gotten out of the way before the last vat would be ready. Most factories have the necessary steam power to run such a separator.

The manufacture of butter from the whey will not ordinarily require much increased labor. The whey can be run through the separator at the same time that the latter part of the cheese making process is going on and the churning will take but a small amount of time and labor. The additional items of expense will be the storage capacity for the whey and the separator. How much this saving might be made to the farmers of this state is shown by the following calculation:

According to the returns made to the Commissioner of Agriculture, there were made in the state of New York in 1892, 130,991,310 pounds of cheese. Estimating that for each pound of cheese there would be 8½ pounds of whey we should have a total of 1,113,426,135 pounds of whey produced in the state. Our whey has contained upon the average .25 of 1 per cent. but our cheese is made in small quantities with special pains to prevent loss of fat in the whey, and the percentage of fat in our whey is undoubtedly smaller than that of the State at large. In Bulletin 65 of the New York Experiment Station, Dr. L. L. Van Slyke gives the average of a large number of analyses of whey made by him during the season of 1893. This work represents analyses of whey made at fifty different factories in eight counties of the State, extending from April to October, and the average of the whole shows .39 of one per cent. of fat in the whey. Assuming this to be a fair average of the percentage of fat in all the whey produced in the State, we should have 4,342,362 pounds of fat lost in the whey. Allowing that the butter contained 85 per cent. of fat and providing for all mechanical losses in the manufacture, we should make from this amount of fat 4,776,598 pounds of butter, which at 20 cents per pound would be worth $995,319, or about 50 cents for each cow in the State.

In nearly all of the factories in the state this butter would find a home market among the patrons of the factory so that expense of packages and marketing need not be taken into account and the saving would be a clear one to the patrons.

HENRY H. WING.

BULLETIN 86—March, 1895.

Cornell University—Agricultural Experiment Station.

HORTICULTURAL DIVISION.

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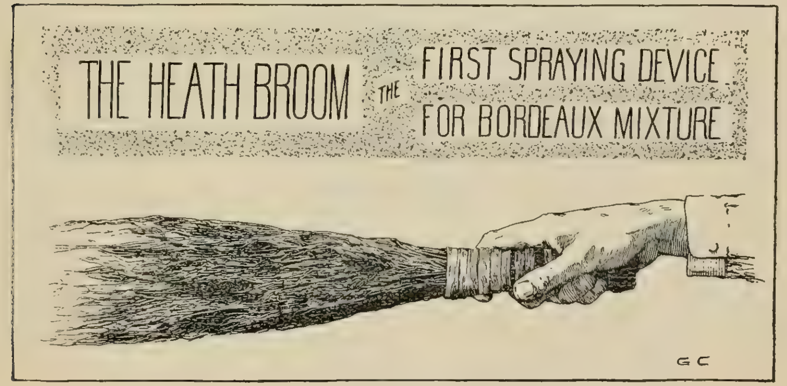
The Spraying of Orchards,

Apples, Quinces, Plums.



By E. G. Lodeman.

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BULLETINS OF 1895.

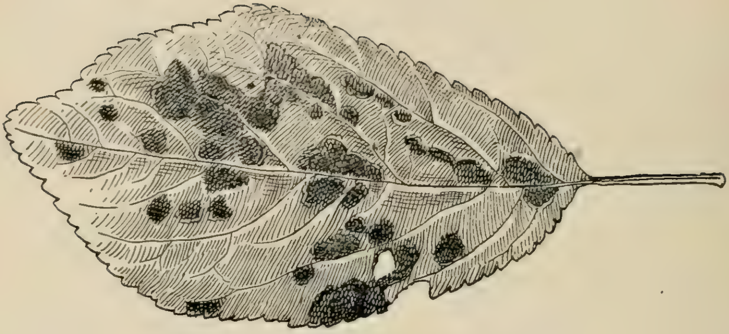
84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.

CORNELL UNIVERSITY,
ITHACA, N. Y., *March* 1, 1895.

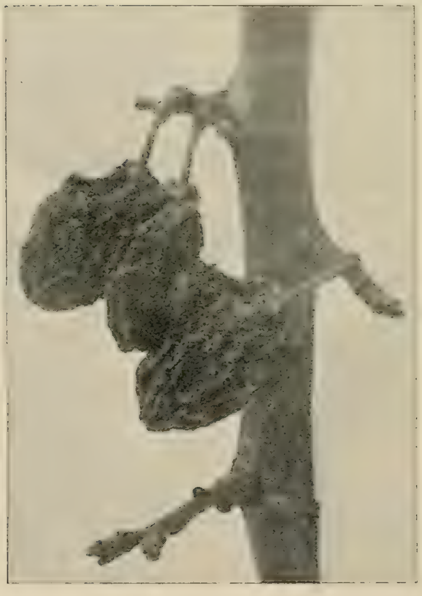
The Honorable Commissioner of Agriculture, Albany:

SIR.— The following sketch of experiments in spraying orchards is submitted for publication under Section 87, Chapter 675, Laws of 1894. This bulletin may be considered to be a complement to No. 84, upon Apple Failures in Western New York. The general conclusions as to the fundamental causes of the recent failures of apples are essentially alike in the two bulletins, but they were arrived at independently by Mr. Lodeman and myself. It is now established that spraying with Paris green and Bordeaux mixture is often capable of rescuing a crop of apples and other fruits from the ravages of insects and fungi; but it is equally well established that spraying sometimes avails little. In other words, some of the failures of orchards to bear are due to insects and diseases, and other failures are due to causes which lie back of these attacks, probably to lack of available food supply. The inference is plain; orchards should be both fed and sprayed.

L. H. BAILEY.



10. Plum leaf injured by fungus. (Page 128.)

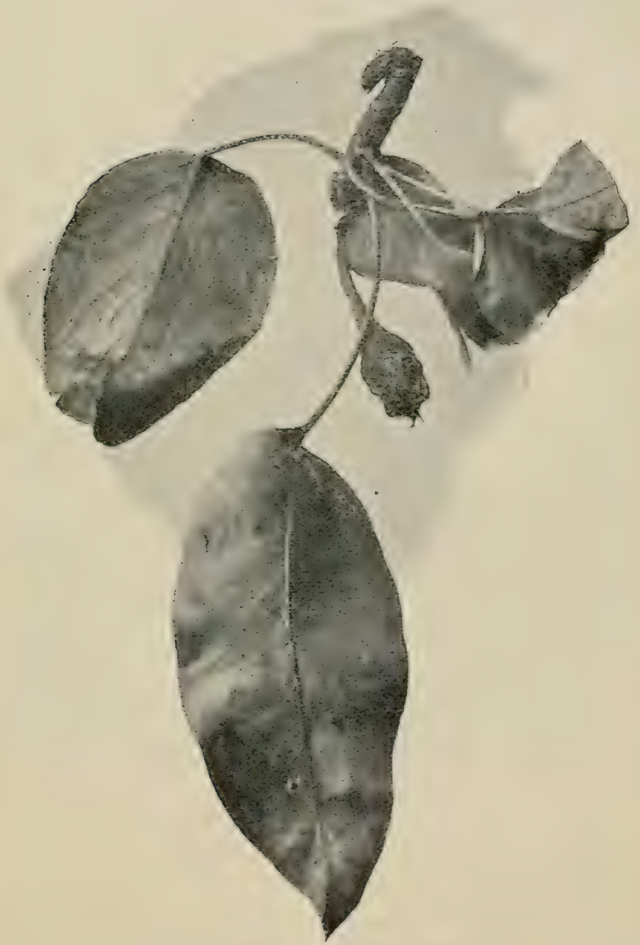


11. Rotting of plums (page 128). The upper fruit spur has been killed by the fungus.

The Spraying of Orchards.

PART I.—NOTES ON THE SPRAYING OF APPLE ORCHARDS.

AT CORNELL.



12.— Pear killed by Bordeaux mixture.

Most of the experiments made by the Cornell Experiment Station during the past season on the spraying of apples were conducted in the orchard of John J. McGowen, who again kindly placed his trees at our disposal. The orchard has now been treated by this station for three years, and it offers in several respects an excellent field for work of this character. In a previous bulletin * a full description of the orchard has been given, so that all the conditions under which the experiments were carried on might be understood. Brief descriptions of the apple scab and of the codlin moth have also been published.† These two pests are the most serious ones against which the apple growers of this vicinity have to contend, and it has been found that by keeping them well under control the foliage and the fruit of the trees remain almost perfectly healthy throughout the season.

But the question is constantly before us as to how we can best control these two enemies of the apple grower. The present methods employed are in a great many ways unsatisfactory. The labor of making the application is difficult and unpleasant; the best time to spray is still a matter of doubt; the amount of liquid to use, the best methods of preparing it, and a host of other unsolved problems are continually arising and demanding answers. These can not be definitely given when based on the work of only one season. One point and then another must be carefully studied, and the greater the delay in coming to a final conclusion, the greater should be its accuracy.

The machinery. — The selection of spraying machinery has proved to be somewhat unsatisfactory. The pumps which have given the best satisfaction are hand pumps constructed practically upon the model of Gould's "Standard," Fig. 905, of their catalogue. Nearly every pump manufacturer makes this style of pump and I have still to learn that one is any better than another. These pumps are comparatively cheap; they are very powerful and durable. Several pumps, smaller as well as larger ones, have been tried at this Station, but the above type has proved to be the least unsatisfactory. The one used has the serious objection, especially when much work is to be done, of being too small.

This fact has led us to try horse-power sprayers in apple orchards. Every man who sprays will welcome with delight any kind of a machine which will give the horse a chance to do the pumping instead of himself, and his delight will probably increase directly in proportion to the amount of spraying he has done in the past. With hope in our hearts we wrote to the Field Force Pump Co. of Lockport, N. Y., and this firm kindly sent us one of their machines for trial. It was taken to an orchard and thoroughly tested until all present were satisfied as to the capabilities of the machine. It worked perfectly, and in fact has done so throughout the year, but from the present light we have upon spraying matters it did not answer the purpose for bearing apple trees from twenty-five to thirty years of age. The two objections found against it were that it did not throw enough liquid to cover a tree as thoroughly

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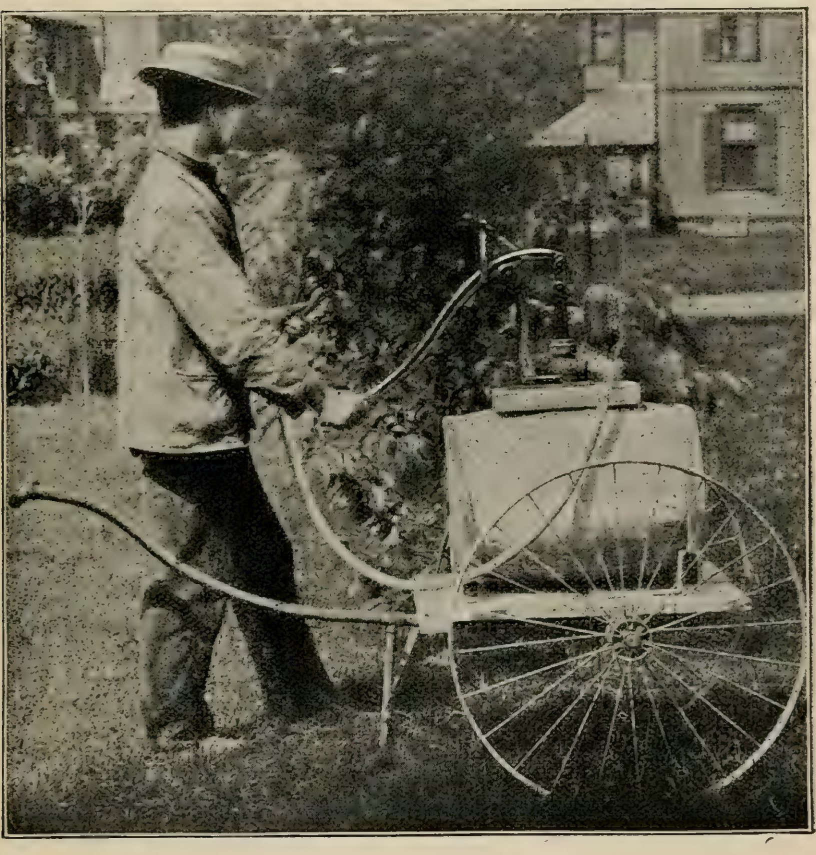
* Cornell Agricultural Experiment Station Bulletin 60, p. 257.

† *Ibid.* Bulletin 48, p. 266, *et seq.*



13. Serviceable spray outfit for light work.

as was desired, and it did not throw the spray far enough for our purpose, although several nozzles were tried. In the vineyard, however, the machine did admirable work and the sprayed vines yielded an almost perfect crop of fruit. It can also be used to advantage in spraying potatoes and other low growing crops, but for orchards this class of machines is as yet of doubtful value. The hand pump has the great advantage of allowing the operator to apply as much liquid as desired upon any given part of the tree. When such a pump is placed upon the side of a barrel, or on a tank having any desired capacity, and then placed upon the wagon so that it can be hauled into the orchard, it makes a very seviceable outfit.

The nozzle which has been used during the past three years is the McGowen, manufactured by Mr. J. J. McGowen of this city. Most of the new nozzles have been tried, but none have yet been found equal to this one for spraying trees.

Figure 13 represents a very serviceable outfit when but little work is to be done, and no large plants are to be treated. The barrel holds about fifteen gallons. It can be drawn quite easily even upon soft ground for the tires of the wheels are broad. The pump is light and powerful, and has answered our purpose in many places.

The weather.— The past spring and summer were remarkable for the great extremes of rainfall and of drought. This applies particularly to the central New York region, for here the rain appears to have been more continuous than in other sections. The official record of the signal service station situated at Ithaca shows the following rainfall from April 1st to October 1st. The sign + denotes increase over the average, and the sign — a decrease :

MONTH.	April.	May	June.	July.	August.	September.
Number of days during which rain fell..........	17	22	18	16	8	13
Total rainfall in inches.....	4.84	7.34	3.40	3.17	.059	5.17
Departure from the average for the month...........	+2.57	+3.10	—.36	—.71	—2.72	+1.23

It will be seen that April was an exceptionally wet month; May shows an increase over the average of 3.10 inches. The precipitation during the first week in June was also heavy. The records show that during the first twenty-three days following May 16, rain fell during twenty-two, and twenty of these were consecutive. The unfavorable influence of such weather upon the successful spraying of apples and other fruits can only be realized when it is considered that there is probably the greatest need of the application at just this time.

An appoximate schedule of the dates of spraying had been made out before the work was begun, and this schedule was followed as closely as possible. The applications were made some in sunshine, and some in rain, and at the time it seemed as if the liquids used were washed off as fast as they were put upon the trees. If the sprayed trees succeeded in becoming dry between the showers, that appeared to be all that could reasonably be asked.

During the last week in June the rainfall practically ceased, and then began a period of drought, more or less severe, which continued until early in September. This prevented the apples from attaining their normal size, but probably had little effect upon the severity of fungous and insect injuries. Not so with the early rains, however. Notes which were taken June 16, at the time of an application, show a very discouraging condition of foliage and fruit. The weather had been warm and moist and there had appeared, during the ten days previous to this time, a vigorous and quite general growth of the scab fungus. All the plots were attacked, and showed fruit that was already one sided, and leaves that were more or less covered by the black, smoky patches of the parasite. In addition to this the young apples were rapidly falling from the trees, and what at first promised to be an abundant yield of fair fruit now seemed to indicate exactly the contrary. When the crop was harvested in September, the yield was indeed small, and it now remains to determine to what degree "the weather" was responsible for the loss.

The materials.—All the applications were made with the sole purpose of combatting fungi. The Bordeaux mixture was almost exclusively used, London purple, and the copper sulphate solution being the only other substances tested for this purpose. The trees sprayed with the mixture were not all treated alike as regards the amount of liquid used, the dates of applications, etc. The

Bordeaux mixture was, with two exceptions, always made according to the formula:

Copper sulphate	6 pounds.
Quick lime	4 pounds.
Water	45 gallons.

Upon two occasions, the mixture was prepared with the assistance of the ferrocyanide of potassium test. The value of this chemical in the preparation of the Bordeaux mixture lies in the fact that when in solution it will combine with dissolved salts of copper and form a compound having a deep reddish-brown color. When sufficient lime is added to the copper-sulphate solution in making the Bordeaux mixture, several new compounds are formed, of which all that contain copper are practically insoluble. If an insufficient amount of lime is used, some of the copper salts remain in solution and the addition of a few drops of the ferrocyanide of potassium solution will produce the characteristic brown color in the mixture; but as soon as enough lime is present to remove all dissolved copper, the test will cause no change to take place. This test solution may be made as follows:

Ferrocyanide of potassium (yellow prussiate of potash)	1 ounce.
Water	1 pint.

The chemical dissolves very readily, and is then ready for use.

When the Bordeaux mixture is prepared in this manner, it contains the smallest amount of lime necessary to satisfy all immediate chemical changes, and upon this fact rests the principal argument for the use of the method. The subject is more fully treated upon pages 120-122.

Copper sulphate	1 pound.
Water	18 gallons.

This was applied as soon as the crystals were dissolved, but it was used only at the time of the first applications, before the buds had fully opened.

London purple was applied by using

London purple	1 pound.
Air-slacked lime	1 pound.
Water	250 gallons.

The lime was added to prevent any caustic action of the poison.

The dates of the applications.—The trees were sprayed upon the following dates:

1. April 21. The buds had burst, but only the tips of the leaves could be seen.
2. May 7. Nearly one-fifth of the blossom buds had opened.
3. May 19. A few of the blossoms were still upon the trees.
4. May 31.
5. June 16.

It was the intention to make one more application about June 30, but at this time so much of the fungicide could still be seen upon the trees that further treatment was thought unnecessary. As but little rain fell during the next two months, the mixture could still be seen upon the leaves in September, so that even if another treatment had been made it would have been of little value.

The rust.—On June 29 the orchard was examined and a serious amount of rust was discovered. It was found that the Red Astrachan, Fallawater, and the King apples showed injured foliage and fruit, partly in consequence of the Bordeaux mixture which had previously been applied. Baldwins were not so seriously hurt, and Fall Pippin showed no trace of any such trouble upon the fruit. Here then was another difficulty, only traces of which had been noticed during the past year but which now appeared nearly as formidable as the scab or the codlin moth. Upon the leaves, it appeared to show itself in the form of reddish-brown areas, generally quite small, and probably of minor importance as regards injury to the tree. Upon the fruit, the affected portions turned grayish brown, and later in the season such portions were rough and appeared yellowish brown in color. A microscopic examination of these injured tissues showed that the coloring matter normally present when the fruit is ripening was entirely wanting, and the walls of the cells that are situated under the epidermis or outer skin of the apple had become thickened and seemed to have acquired a corky texture. Any external irritation of the apple may cause such a formation, and it undoubtedly was so caused last spring. This subject is more fully discussed on pages 120-122.

Grading the apples.—In 1893 the apples of this orchard were graded upon the following basis: "The amount of scab or other fungous injury upon an apple determined its grade, the injury done by worms being rather secondary, for the apples were comparatively little damaged by them." * In consequence of this standard it frequently became necessary to place a commercially first-class apple into the second or possibly into the third grade. The orchard had been sprayed with arsenites so that the worms did not do any serious damage. This year, however, the worms were allowed to have everything their own way, for no applications were made which were designed to destroy them. All applications were made with the sole object of combating the scab, and so in the final grading, insect injury, to whatever extent it may have taken place, did not prevent an apple from entering the first class. It was only on account of fungous injury that affected apples were removed. Since the apples were very wormy (see page 116) it made the first grade appear anything but fancy fruit, although the selection had been made in conformity to the principles laid down when the work was undertaken.

Another factor which rendered the grade more difficult was the rust, of which mention has already been made. In some cases it was practically impossible to determine whether a certain injury was caused wholly by scab, or by rust. It was too late in the season to tell accurately the cause of a blemish upon an apple. Fortunately such cases were not very common.

In order to simplify the table, the figures showing the number of apples in each grade represent what per cent. of the total yield of a plot the given grade formed. The trees bore a light crop, (see page 117), the Kings averaging scarcely three bushels per tree, while the Baldwins and the Fall Pippins bore less than two bushels each. Such a small yield was disappointing, for it is desirable to have as many apples as possible to get at the true value of an experiment. Nevertheless the figures given on the following pages are quite accurate. Some of the experiments made were solely for the purpose of verifying results which had been attained here and at other stations, and with scarcely an exception the results have been practically the same as in past years when larger crops were borne. The King trees in particular were very uniform in this respect. Unfortunately, some of the trees of the other varieties bore hardly an apple and in such cases, of course, not even an approximate conclusion could be reached. On this account several experiments planned were without result. Those upon which reliance could be placed are given below.

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* Cornell Agric. Exp. Sta. Bull. 60, p. 264.

The number of applications necessary.— The King tree selected for this experiment showed considerable difference in the quality of the fruit, as shown in the table. They were treated with the Bordeaux mixture and as nearly as possible the same amount of liquid was applied to each tree.

TABLE I.— SHOWING THE VALUE OF VARYING NUMBERS OF APPLICATIONS

NUMBER OF APPLICATIONS.	First class.	Second class.	Third class.
0	7	27	66
2	42	55	4
4	58	34	9
5	52	46	2

Probably the most interesting feature of the table is the effects produced by only two applications. These were made May 7th and May 19th. The number of first-class apples was increased from 7 to 42 per cent. while the third-class fruit diminished from 66 to 4 per cent. The additional treatment given the other plants show still greater benefits but not in the same proportion. The plot treated four times shows considerably more first-class apples, and the apples of the second class were also decidedly less attacked by scab and were consequently more handsome. This lot also shows an increase in the third quality, yet this can scarcely be attributed to the spray which produced such favorable results in the plot treated but twice. The apples from the trees which were sprayed five times, all grades considered, were not much better than those receiving four treatments. This is practically the same result which was obtained last year* with this variety. The comparatively slight difference between the fruit treated twice and that treated four times suggests the use of only three treatments, and if only this number had been made, it would in all probability have been sufficient. The other varieties treated in these plots did not yield sufficient fruit for safe comparison.

The two most important applications.— It has been shown in former bulletins from this station, as well as in those from other stations, that the most important treatments are those made in the spring. The use of only two applications has been followed by such good results with some varieties that this number seemed to be sufficient to control the apple scab. But the best time for making these treatments can not be stated unhesitatingly. Two applications were therefore made at different times to certain King and Baldwin trees to discover if possible which treatments were the most effective. Three plots, or divisions were made:

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* Cornell Agric. Exp. Sta., Bull. 60, p. 267.

1. Two applications made before the blossoms opened: April 21th, copper sulphate solution; May 7th, Bordeaux mixture.

2. One application made just before and one immediately after the blossoming of trees; May 7th and May 19th, using Bordeaux mixture.

3. Two applications after the blossoming of the trees: May 19th and May 31st, Bordeaux mixture.

Table II.— Showing Effect of Two Applications Made at Different Times.

DATE OF APPLICATIONS.	KING.			BALDWIN.		
	First class.	Second class.	Third class.	First class.	Second class.	Third class.
None................	7	27	66	7	20	73
April 21............	....	....	....	....	....	.....
May 7..............	26	53	22	18	40	42
May 7..............	....	....	....	....	....	.....
May 19.............	42	55	4	35	35	17
May 19.............	....	....	....	....	....	.....
May 31.............	46	47	7	48	30	22

The yield from untreated trees is given in the above table for comparison. The trees receiving the two earliest treatments were greatly benefited by them. The number of third class apples was reduced from 66 per cent to 22 per cent, in the case of the King and the Baldwin showed a reduction from 73 to 42. There was also a marked increase in the number of first class and second class apples of both varieties.

Turning to the second division, those treated May 7 and May 17, we find that a still greater difference has been made by these two applications than by those of the first division. The King in particular shows this difference, there being only four third-class apples, but forty-two in the first class. The Baldwin also shows a marked improvement, but it is not so decided as in the case of the other variety.

The apples of the third division do not differ much from those of the second. This is especially true of the King apples, there being a few more first quality fruits, but also more of the third grade. The Baldwins show a similar increase, but it is still more marked in the first class fruit. (See also p. 124, The Nixon orchard.)

Having thus briefly considered the character of the fruit, it will be interesting to note which treatment has been followed by the best results. The first two applications did not produce the fairest fruit, while that of the second division, in the case of the King apples, was equal to any borne by the trees. The Baldwin also showed such an improvement that it will be safe to say the application made April 21 was not so valuable as that made May 7. In the third division the Baldwins show a still greater improvement, and it would appear from them that the treatments made May 19 and May 31 were the most valuable. Such may have been the case this season, but in 1892* it was found that when the first application was made as soon as the blossoms fell, the scab had already secured an entrance into the fruit and the foliage of the trees. Taking this fact into consideration, it would appear that the most important treatments for apple scab† are those which are made just before the blossoms open and soon after they fall, this statement being, to a certain extent, dependent upon the season.

The amount of liquid to apply.—I have so often seen men spraying their trees with much less liquid than it has been our custom to apply, that one part of the orchard was this year used to determine the effect of applying different amounts of the Bordeaux mixture. Six King trees, well grown, and nearly thirty years of age, were selected for the purpose. Two were treated with two gallons of the mixture at each application; two with three gallons and two with four gallons. Care was taken to distribute the smaller amounts of liquid as evenly as possible, so that it should not be applied in patches.

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* Cornell Agric. Exp. Sta. Bull., 48, p. 269.

† The treatments to be made for the codlin moth have been discussed in Bulletin 60 of this Station.

TABLE III.—SHOWING THE VALUE OF DIFFERENT AMOUNTS OF FUNGICIDE.

GALLONS OF LIQUID.	First class.	Second class.	Third class.
0	7	27	66
2	39	53	8
3	48	47	5
4	49	46	5

The average of the check trees is here again used for comparison. The marked benefits derived by applying only two gallons are seen at a glance. The improvement is still greater where three have been used. Four gallons did not make sufficient difference, as shown by the table, to make the use of this amount desirable. Judging only from the table, therefore, it would appear that the proper amount of the Bordeaux mixture to use on trees of this size, provided the liquid is well distributed, is between two and three gallons.

But figures are not the most satisfactory things to deal with, especially when they refer to the grading of apples. The table does not show that the size, symmetry and fairness, the rust of course excepted, increased almost directly in proportion to the amount of the mixture used. It does not show that the apples which received but two gallons at each application were only about two-thirds as large as those which were treated with four, yet such was the case, nor is the degree of insect injury hinted at. Nevertheless, the apples which had been most thoroughly sprayed showed fewer insect injuries; I refer particularly to those many kinds that are so commonly seen upon the surface of the apples, and not to the codlin moth. This permitted a more regular growth to take place, and the apples treated with four gallons of the Bordeaux mixture were decidedly superior to those treated with only three. Although this result was entirely unlooked for, it was so evident that it could not escape notice. Now the question arises, does the Bordeaux mixture have any influence in keeping insects from fruit, or does it merely encourage growth? The scab did not influence this result, for it was upon the amount of scab present that the apples were graded.

The effect of former applications upon the crop of 1894.— It has been the custom to leave an additional check tree each year since work in the orchard began. There were three King trees left unsprayed this year; one had never received treatment, another had been sprayed in 1892 only, and the third in 1892 and again in 1893. The trees when sprayed had received liberal applications of the Bordeaux mixture.

TABLE IV. — SHOWING THE EFFECTS OF FORMER APPLICATIONS OF FUNGICIDES ON THE CROP OF 1894.

TREATMENT.	First class.	Second class.	Third class.	Amount yielded
Never sprayed	6	26	68	1 bu.
Sprayed in 1892	4	23	73	½ bu.
Sprayed in 1892, 1893	12	31	57	1¾ bu.
Average	7	27	66	1.42 bu.

The table does not offer much hope to the lazy man, for the scab is nearly as abundant upon one plant as on another. There is some difference in favor of the tree which was treated twice but it is not great enough to encourage an apple grower to neglect the care of his trees; yet one circumstance must be taken into consideration. These trees are situated in an orchard which is only partially well sprayed. There has not been a systematic effort to exterminate the disease upon the trees, which might make a greater difference than is shown by the table.

The early use of the copper-sulphate solution is closely related to this subject. It may be possible to free the trees from the scab fungus before the buds break by destroying it so early in the season, but the results obtained in the orchard this year do not encourage the plan. The proximity of untreated trees probably exerted an unfavorable influence. Yet what orchard, even if entirely so treated, is so isolated that it may not be infected from another in the neighborhood? Until more work has been done, it seems advisable to spray the young fruit as suggested by Table II, on page 114.

London purple as a fungicide — Since the establishment of the fact that Paris green possesses considerable value as a fungicide, its use upon trees which are being treated for fungi, to determine the comparative value of different materials, is not advisable. London purple was this year applied to one-half of a Fall Pippin tree to discover if the scab would be affected by the applications. Five treatments were made. This variety of apple is generally very much injured by scab, but it may also be protected quite easily by the use of proper fungicides. Some trees to which the Bordeaux mixture had been applied produced very large and fair fruit. But those treated with London purple showed absolutely no benefit from the application, neither upon the foliage nor upon the fruit. The poison contained nearly seventy-five per cent. of the normal arsenite of calcium, and had been used with success against the codlin moth in previous years.

The value of former applications of arsenites.— No treatments were made this year that were connected with the destruction of the codlin moth. During the past two years the orchard had been so thoroughly sprayed with arsenites that it was supposed these applications might have had considerable influence in the extermination of the pest. There is no large apple orchard near the one treated. And this comparative isolation, it was hoped, would not be without its influence. But as the season advanced the consequences of this neglect became more apparent. Not only did the codlin moth flourish, but also nearly every insect that could in any way disfigure an apple. The curculio was very prevalent, and assisted in the disfigurement of nearly every apple in the orchard. The light crop appeared to compel the insects to concentrate their efforts upon the few apples that were borne, and rarely has a crop of apples shown more clearly the extent to which insects alone can ruin fruit. The average amount of injury obtained from several trees of different varieties, treated and untreated, showed that 76 per cent. of the fruit had been attacked by the codlin moth; the lowest figure obtained was 70, from a tree thoroughly sprayed with the Bordeaux mixture, and the highest 80, produced by an unsprayed tree. If other insect injuries had been considered, the per cent. would undoubtedly have been nearly 100.

Doubt is sometimes expressed as to the comparative seriousness of the apple scab and the codlin moth. It is probable that if the insects had been controlled in the orchard instead of the fungi, the injury done would have been less. And this leads us to the question of the comparative value of all applications. In apple orchards I am convinced that Paris green is the most valuable material that can be used as it is our safest insecticide and possesses also strong fungicidal properties. When to this poison is added properly prepared Bordeaux mixture, the apples borne by the trees should be gathered in almost perfect condition.

Spraying as affecting the bearing of orchards.— The apple-scab fungus has been held responsible for many if not all of the failures of the New York apple orchards to bear during recent years. It was supposed to destroy the young fruit after the blossoms fell, or the blossoms themselves were so injured by the fungus that the fruit did not set. There is undoubtedly much foundation for this theory. Mr. L. T. Yoemans, of Walworth, N. Y., showed me a row of Baldwin apple trees which had failed to produce any fruit during the past year. This row was the outer one of the orchard and it was so close to the next one on the interior that a spray cart could not enter. For this reason it was not treated, and although the remainder of the orchard, which was well sprayed, yielded an enormous crop, this untreated row scarcely bore an apple. The age of the trees, soil, cultivation, and other circumstances were the same in both cases.

This theory will not always explain the non-bearing of apple orchards. The one which has been treated by this Station during the past three years has had liberal applications of fungicides and insecticides, with the exception of this year, yet it has not borne a full crop for many years. In 1893 a little more than half a crop was produced, but in 1892 and again the past season the crop was very small. One of the objects of leaving a check tree each year as already described, was to determine the extent to which the theory would apply to the McGowen orchard. The treatments have been of some benefit, for the sprayed trees averaged more than twice as much fruit as the unsprayed, but still the yield was very light. Some orchards appear to bear independently of spraying. There is some other cause for the trouble and I believe it may be improper cultivation or fertilization. Several years will be required to determine this point, but the station has the work now under way, and the results are awaited with considerable interest.

The causes of the rust.— The exact cause of rusty fruit is difficult to find, and as so often happens when the reason for a certain fact is unknown to us, we lay it to the weather. The weather then, considering its nature and the unusual abundance of rust even in unsprayed orchards, may be considered as one of the prime factors which brought about the trouble. Since such an unusual amount of rain fell, this excess of moisture alone may have brought it on.

When we come to sprayed orchards, the severity of the rust increases, probably on account of the chemicals used, and not in consequence of the water applied, as this amount is comparatively small. One of the most severe cases of rust noticed was in the orchard of John W. Spencer, Westfield, N. Y., and these trees had been thoroughly sprayed with the Bordeaux mixture and London purple. In the trees sprayed by this station the rust appeared to increase with the number of treatments, and those which were sprayed with the Bordeaux mixture made with the potassium ferrocyanide test showed the discoloration most strongly. Mr. Spencer used the same test in making his Bordeaux mixture and from all appearances the trouble has been aggravated by the use of the chemical. In the orchard of a prominent fruit grower a pear crop was practically ruined apparently by the early use of Bordeaux mixture prepared with the aid of this test. Fully seventy-five per cent. of the fruit fell to the ground soon after the application was made, while in a neighboring orchard containing similar varieties, the the fruit remained upon the trees.* (See initial illustration, p. 105.) The test, therefore, would seem to be unsafe unless more lime is added than appears to be necessaary. The lime will not prevent the trouble, but it may assist in lessening its severity. The formula given on page 110 seems to be as satisfactory as any yet proposed in this country. I have learned, however, that in some parts of Italy a much more dilute mixture is used on grapes, with entire success. The formula recommended in the past by this station is made approximately of a one and eight-tenths per cent. (1.8 per cent.) solution of copper sulphate, considering the crystals as weighing 6 pounds and the forty gallons of water 333 pounds. The Italian mxiture calls for only seven-tenths of one per cent. (.7 per cent.) which is equivalent to diluting our mixture to about 104 gallons. Applications made with such a fungicide may not encourage rust,

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*See also *Garden and Forest*, vii. p. 456 for a more complete account of this orchard. The danger of using the Bordeaux mixture made with the ferrocyanide test, was indicated in Bull. 74, p. 382 and 84, p. 12. At about the same time Fairchild's bulletin upon the Bordeaux mixture (Bull. 6, Div. Veg. Path. Dept. Agric.), expressed a doubt as to the advisability of using the ferrocyanide test.

but it might not be equally efficient against the apple scab. The Italian growers also confess to the necessity or making a greater number of applications when such dilute mixtures are used.

The experiments of Sostegni, some of which have already been referred to in a former bulletin,* have a direct bearing upon this subject. In a later article † he emphasizes the value of having a certain amount of dissolved copper present in the Bordeaux mixture. The chloride of ammonia is added to increase the amount of copper in solution. The solvent action of carbonic acid as found in rain water and dew is also mentioned. The dew found upon grape foliage which had been sprayed was very carefully absorbed by blotting paper and then analyzed for copper. It was found that when ordinary Bordeaux mixture had been applied, in four cases out of five no copper was found in these tests. When the mixture had been prepared with a small amount of lime some copper was found in every case. But the addition of the chloride of ammonia caused a large increase in the quantity of copper held in solution.

In a later paper, ‡ the same writer gives an account of other experiments from which he draws the following conclusions:

1. The principal cause of the solution of the copper is the carbonic acid dissolved in the water which bathes the leaves upon which the Bordeaux mixture has been placed. This explains why the dew that has absorbed this gas acts with great energy as a solvent of the copper compounds.

2. When the leaves treated with the Bordeaux mixture remain for some time in contact with the moist air a large part of the copper compounds become gradually soluble. On this account rains may carry away large quantities of the dissolved metal; and it follows that very frequent rains, although of short duration, dissolve and waste more of the fungicide than do more severe rains which follow each other at longer intervals.

3. A great excess of lime in the Bordeaux mixture diminishes the amount of copper held in solution in the clear liquid. When such a mixture is applied to foliage the copper is less widely distributed, and can only be found in these places in which solid particles of the mixture have lodged. The lime retards the solvent action of the carbonic acid gas, since before the latter can act upon the

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* Cornell Agric. Exp. Sta. Bull. 48, p. 291.

† Sostegni, *L'Agricoltura Meridionale*, 1891, No. 17, pp. 261-263.

‡ Sostegni. *Giornale di Viticoltura, Enologia, ed Agraria*, 1893, Nos. 12 and 13.

copper compounds the lime must be changed from the hydrate into the carbonate. This may be of advantage during seasons of frequent showers for in such cases less of the copper would be washed from the leaves and lost.

After our experience of 1894 it would appear to be very advisable that an excess of lime be used in making the Bordeaux mixture. But this excess is not put in for the purpose of lessening the waste of dissolved copper, but that foliage and fruit may not be injured by its presence. The conditions of dry climate existing in Italy, are evidently very different from those found in America, for here dissolved copper is injurious while there it is desired.

THE WORK DONE ELSEWHERE.

By station workers.—The results obtained by Munson * indicate that a combination of the Bordeaux mitxure and of Paris green was more effective in preventing apple-scab than was either the Bordeaux mixture used alone, or eau céleste. The result shows that Paris green possesses fungicidal properties, but in this case they are not so strongly marked as has been reported from other stations.

Stinson * has found that when apple trees are thoroughly sprayed the total number of windfalls is considerably reduced. The greater part of those from the check tree fell early in the season, while from the sprayed trees they fell mostly when large enough to use. At the time of the harvesting, the sprayed trees yielded nearly twice as much fruit as that obtained from the unsprayed trees. The season's work (1893) goes to show that three or four treatments are sufficient to control apple scab, and it was also noticed that trees which were "sprayed but twice gave about the same per cent. free from scab as those sprayed three times, but the apples were not so large as those sprayed three times."

By growers.— T. H. Walker, Ripley, sprayed R. I. Greening, Baldwin, Twenty-ounce, N. Spy, and a seedling variety, with Paris green and the Bordeaux mixture. The apples were more wormy than was expected, the trees showing from fifty to ninety per cent. of affected fruit. This was undoubtedly very largely due to the fact that the first application of Paris green was not made until May 23, twelve days after the blossoms fell from the trees. A second application of Paris green was made June 6. The falling of the apple blossoms is the signal for the use of arsenites in the destruction of the codlin moth.

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* Maine Agric. Exp. Sta. Bull. 8, Second Series.

* Arkansas Agric. Exp. Sta. Bull. 26.

The orchard was sprayed four times with fungicides; the first application was with the copper-sulphate solution; the following ones were with the Bordeaux mixture. They were made on the following dates: April 9, April 21, May 2, June 6. The fruit was practically free from scab. The seedling variety had never borne perfect fruit before having been sprayed, but this year the tree was loaded with good fruit free from scab.

Rust was found upon most of the varieties to a considerable extent, and there appears to be no doubt of the injurious action of the Bordeaux mixture in these cases.

Mr. Tenant, of Ripley, sprayed an orchard three times, using only the Bordeaux mixture and Paris green. The former was used alone for the single application made before the blossoms appeared, but the two were applied together as soon as the blossoms fell, and again about ten days later. From one to two gallons of the mixture were used per tree. In spite of the use of this small amount of liquid, the crop harvested was very fair and the owner is enthusiastic regarding the value of the treatment. The varieties grown are mostly Baldwins, Roxbury Russet and King. Rust was found throughout the orchard, but it was not so serious as in that of Mr. Walker.

John W. Spencer, Westfield, sprayed his apple trees very thoroughly the past season, making all the applications generally recommended. The crop, however, showed that careful work added to even the best intentions will not always produce perfection. Mr. Spencer's apples suffered severely from rust, and they were exceedingly wormy, so much that they could not have been much worse if no application had been made. The reason for this trouble was discovered, but too late to remedy it. London purple had been used in place of Paris green, and it was so deficient in arsenic that about a pound to forty gallons was required to destroy potato beetles. It had been used upon the apple trees at the rate of one pound to nearly two hundred and fifty gallons of water, so of course its action was very slight.

The Bordeaux mixture was made with the use of the ferrocyanide of potassium test. This undoubtedly had much to do with increasing the amount of rust upon the fruit, for the applications were thoroughly and frequently made.

Charles Colburn, Ripley, sprayed his apple trees once, using Paris green and the Bordeaux mixture. Trees which in former years produced cracked fruit that dropped prematurely to the ground, this year produced fruit that remained upon the trees and matured in much better condition. Only about one and a half gallons of the mixture were used per tree. The applications will be made again in 1895.

H. A. Blowers, Westfield, sprayed his trees with London purple as soon as the blossoms fell to the ground, and repeated the application about three weeks later. No marked difference could be seen between the trees which were sprayed and those which were not treated, but another trial will be made during the coming year.

E. W. Skinner, Portland, sprayed his orchard about the middle of June and again ten days later, using the Bordeaux mixture and Paris green. Although there was an apparent benefit derived from the treatments, the fruit being about one-third larger, better results might have been obtained if earlier applications had been made. The orchard will be more thoroughly treated next year as the work appears to pay.

F. W. Howard, Fredonia, says he made the first application to his orchard about five days after the falling of the blossoms, using the Bordeaux mixture and Paris green. This was repeated in about ten days. In the fall the apples were of poor quality, the treatment having done apparently no good. The cause of this failure can scarcely be explained unless it is the fungicide was not applied sufficiently early.

Judge Barker, Fredonia, sprayed Baldwin, Greening, and Spitzenburgh trees with Paris green as soon as the blossoms fell, and in about a week the trees were again sprayed, this time with the Bordeaux mixture as well as with the Paris green. A third treatment was also given the trees, only the Bordeaux being used. The apples gathered in the fall were exceptionally fine. The trees were loaded and the fruit was nearly perfect. This crop was undoubtedly the finest it was my pleasure to see last fall.

The orchard of Hon. S. F. Nixon was treated for the apple scab and for the codlin moth. Work was begun late in the season, the first application being made May 24th, the second May 31st. The Bordeaux mixture and London purple were used in combination for each treatment. The Bordeaux was made with the ferrocyanide of potassium test, and the arsenite was the same as that used by

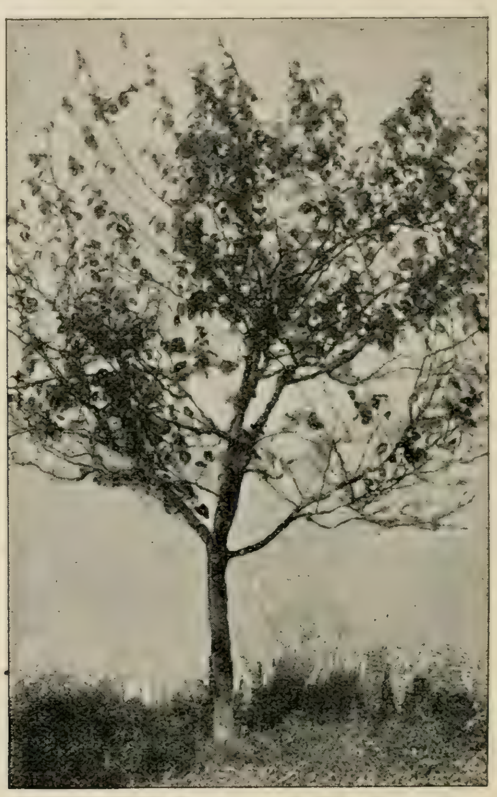
Mr. Spencer, already mentioned on the preceding page. In spite of the late beginning some good was done. The number of first-class apples upon the Baldwin trees was as follows: unsprayed 2.7 per cent., sprayed 7 per cent.; upon the R. I. Greening, unsprayed .034 per cent., sprayed 3.8 per cent. The second-class fruit on the sprayed trees was also decidedly superior to the same grade of the unsprayed. The grain is small, and goes to emphasize early application and the use of good material.

H. B. Clothier, Forestville, sprayed an orchard in which several varieties were growing, including trees of Baldwin, N. Spy, Greening, and Roxbury Russet. The orchard was sprayed as follows: First, when the buds were nearly ready to burst; second, when the blossoms had fallen, using Bordeaux mixture and Paris green; third, ten days later with same combination; fourth, ten days later, repeated the last. The leaves were then somewhat affected with scab, but the apples were nearly perfect. On July 5th, the condition of the trees was about as follows, the figures denoting the per cent. free from scab: Baldwin, 90; N. Spy, 95; R. I. Greening, 78; Roxbury Russet, 83. This was a decided improvement as could be seen from a neighboring orchard in which similar varieties are grown. The rust was quite serious, but the gain from the application far overbalanced the loss caused by this defect.

PART II.—SPRAYING QUINCES FOR LEAF SPOT, AND THE CRACKING OF THE FRUIT.

Quinces in all parts of this state are almost invariably attacked by a fungus (*Entomosporium maculatum*). This causes the formation of small circular brown spots upon the foliage, and if a leaf is attacked in several places, those spots may unite in the formation of considerable areas. Such leaves generally assume a yellowish appearance, and they soon drop from the tree. Many trees are entirely defoliated each year by the fungus, the fruit in some instances still persisting. (See Bulletin 80).

The fungus attacks the fruit as well as the foliage. When this takes place early in the year the affected part is checked in its growth, and in consequence the fruit becomes misshapen, and in some portions corky. It may even split open, and is of course rendered entirely worthless for market. Fortunately, however, this disease does not appear to be very active early in the year. I have rarely seen any serious attack before the first of July, and sometimes it is nearly the first of August before much injury is done. These later attacks cause the fruit to appear spotted with small, nearly black, sunken places which do not materially affect the form of the quince, but which nevertheless disfigure it. The fungus thrives in warm, damp weather, and its appearance and severity are largely dependent upon these conditions.



14.—Angers quince, not sprayed.

The treatment of this disease is simple and effective. Some good fungicide, as the Bordeaux mixture or the ammonical solution of copper carbonate should be sprayed upon the trees early in the summer, the date of the first application depending upon the season. Fig. 14 shows an unsprayed Angers quince tree, while Fig. 15 shows one which was treated. This received application of the Bordeaux mixture May 18, June 6, June 28, July 16 and August 2.

This number of treatments was unnecessary, for other trees which were not sprayed until June 6th showed foliage which was apparently just as healthy. The very wet weather seemed to bring on the disease earlier than usual, but trees which had been sprayed resisted the attacks almost perfectly. The fruit was very fair and large.

15.—Angers quince, sprayed.

That borne by trees which was sprayed later, beginning June 28th, was more or less spotted, and showed that the work had not been done early enough. Yet in 1891 some quinces which were not sprayed before July 13th preserved their leaves practically uninjured until very late in the fall. Applications which are made to quinces, as well as to so many other fruits, must be made intelligently and with some regard to the season.

PART III.—NOTES ON SPRAYING PLUMS

In spraying our plum trees for the black knot, of which a report has recently been published,* notes were taken regarding the action of these applications in checking a fungous disease known as leaf spot (*Septoria cerasina*), causing an appearance resembling that shown in Fig. 10, and the rotting of the fruit, Fig. 11, also caused by a fungus (*Monilia fructigena*). Several varieties received the application, a list being given below, but one unsprayed tree was left in each plot.

More treatments were made than are required for the control of these diseases, but the dates of all applications are here given: March 8, 13; April 20; May 2, 30; June 28; July 16; August 1. If any plum diseases are susceptible to treatment by the use of fungicides these trees should have been free from them.

The leaf-spot or "shot-hole" fungus of plums first appears during early summer. It causes the formation upon the foliage of small, dark-brown or purplish spots. Such portions soon fall from the leaf, which then appears to have been riddled with shot. Those which are most seriously affected turn yellow and fall to the ground. In this way trees are very often defoliated.

This disease can easily be controlled by making the following applications:

First. About two weeks after the blossoms have fallen, apply the Bordeaux mixture.

Second. Repeat first in two or four weeks, depending upon the season.

Third. Repeat the first in two to four weeks after the second, if necessary.

The fungus which causes the rotting of the fruit, also attacks the smaller branches, particularly of plums and peach trees. It may penetrate the fruit and even the blossoms early in the year, but it generally is most serious when the plums are nearly full grown. The fruit turns brown in the affected parts, and this color spreads rapidly throughout the fleshy parts and the rotting of the fruit is soon accomplished. Such fruits may remain upon the trees, often fastened together where they come into contact with each other, and they may still be seen the following spring, where they form centers of distribution of the spores which spread the disease during the warm days of the new year. If not controlled it is a very serious disease and has caused the entire ruin of many crops of plums and of peaches.

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* Cornell Agric. Exp. Sta. Bull. 81.

The most important treatments made to control this disease are probably the following:

First. Spray the trees before the buds break with the copper-sulphate solution.

Second. When the blossoms have fallen apply the Bordeaux mixture.

Third. When the fruit is about two-thirds grown, repeat the second.

Fourth. If necessary spray with the ammoniacal solution of copper carbonate.*

That part of the following table relating to the fruit rot has been prepared from notes taken August 25th. Notes on the leaf spot were made October 18th, when the effects of the treatments were most visible. The figures represent the degree of perfection of the foliage and of the fruit, so the greater the figure the less is the severity of the disease.

NAME OF VARIETY.	Fruit Rot.		Leaf Spot.	
	Check.	Sprayed.	Check.	Sprayed.
Bavay's Green Gage.......	70	90	50	95
Bradshaw................	......	......	50	80
Coe's Golden.............	......	......	100	100
Fellenburg...............	......	......	......	100
Gen. Hand...............	......	......	95	100
German Prune............	......	......	......	95
Imperial Gage............	50	90	90	95
Jefferson	85	80	100	100
Lombard.................	70	95	90	100
McLaughlin...............	......	......	10	95
Niagara..................	......	90	100	100
Quackenbos..............	......	......	75	90
Shipper's Pride...........	90	90	85	90
Smith's Orleans...........	90	90	25	00

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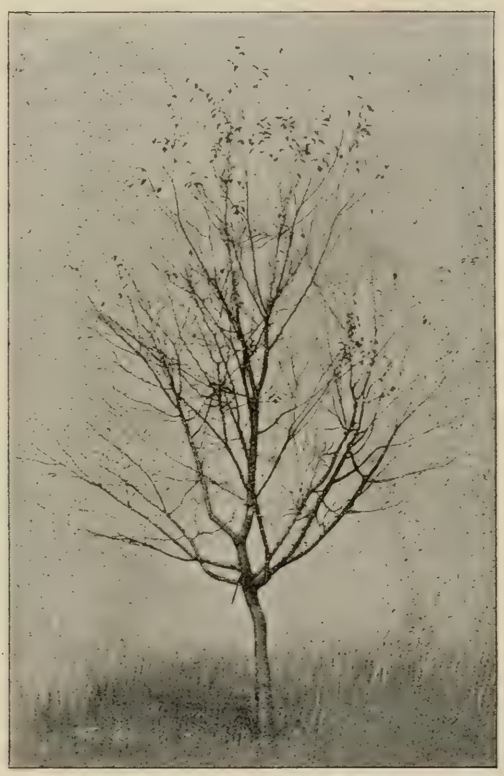
* This fungicide is made by dissolving one ounce of the carbonate of copper in ammonia, and then diluting the solution with nine gallons of water. Before dilution, the blue ammonia liquid should be kept in tightly corked bottles. It may then be used as required.

It is interesting to note the difference in the degree to which the varieties were affected. The Niagara suffered most from fruit rot, every plum having been destroyed, for a good crop set early in the season. Varieties which are followed by leaders produced no fruit. Imperial Gage lost about one-half of the crop from this disease, while Bavay's Green Gage and Lombard lost about thirty per cent. In the other varieties the loss on the check trees was less severe. No variety of the sprayed trees lost more than twenty per cent. by rot, and this amount occurred only in the case of the Jefferson, it being five per cent. less than the check. I can not explain this loss. The loss in the other varieties was only five or ten per cent.

16.—German prune, sprayed.

The foliage showed some difference when the first notes were taken but not so much as later in the season. Fig. 16 represents a tree which was sprayed, while Fig. 17 represents another of the same variety which received no treatment. The photographs from which the illustrations were made were taken October 18th. The entire loss of foliage, even though it occurs but a week or two earlier than under normal conditions, must weaken the tree to a certain extent, and the earlier this loss takes place the more will the tree be injured. There is nearly as much difference in the extent to which the several varieties of plum foliage are attacked by leaf spot, as in the case with the fruit and the fungus which causes the rotting.



17.— German prune, not sprayed.

The foliage also shows much difference in the powers of the varieties to resist disease. Fellenberg and German Prune had lost all their leaves from the check trees, while the sprayed trees still retained their leaves in an almost perfect condition. Bradshaw was also seriously affected. Coe's Golden, Jefferson and Niagara showed no fungous disease upon either the sprayed or the unsprayed foliage, but all the other varieties were more or less attacked.

The large number of applications which were made this year seemed to have an influence upon the thickness of the foliage. Leaves were taken October 15th from sprayed and unsprayed trees of three varieties of plum, Fellenberg, Bradshaw and German Prune. Five leaves were selected for each lot, and they were taken from corresponding portions of the trees. In making the selections the material was uniformly cut from near the mid rib, in the vicinity of the center of the leaf, so that no error might creep in from this direction. The average of the measurements are as follows:

Fellenberg, sprayed 10.6 micromillimeters; unsprayed 10.4 m., a gain of 1.9 per cent.

Bradshaw, sprayed 10.9 micromillimeters; unsprayed 10.6 m., a gain of 2.8 per cent.

German prune, sprayed 12.9 micromillimeters; unsprayed 11.7 m., a gain of 10.2 per cent.

The differences between the sprayed and the unsprayed foliage, although very slight in cases of the first two varieties, are nevertheless uniformly in favor of the sprayed foliage. This is most plainly shown in the leaves of the German prune. It would appear that the Bordeaux mixture has an influence upon the foilage causing it to become thicker, or that the increased vigor of the tree brings about this result. It has often been said by careful observers that apple foliage is benefited by such applications, ignoring entirely the protective action of the Bordeaux mixture against fungi. The particular cells of the plum leaves which were enlarged could not be determined with certainty, but the palisade cells appeared to be longer in the sprayed leaves.

SUMMARY.

1. Hand pumps have proved the most satisfactory machine for spraying apple orchards.

2. Power sprayers have proved unsatisfactory because they do not throw enough liquid, and they do not throw the spray far enough.

3. Power sprayers are excellent machines to use in spraying grapes and low growing plants.

4. Rusty fruit was found upon Baldwin, King, Red Astrachan and Fallawater trees, but none upon Fall Pippin.

5. Four applications of the Bordeaux mixture made to King trees protected the fruit well from scab, but it is probable that three would have been sufficient.

6. The two most important applications made for combating the apple scab consist of the one which is made just before the blossoms open, and the one made as soon as they fall.

7. If a third treatment is advisable it should be made about two weeks after the falling of the blossoms.

8. The use of three gallons of Bordeaux mixture upon bearing trees from twenty-five to thirty years of age, seems to be advisable; for a part of the beneficial action of this fungicide may be the lessening of insect, especially curculio, injuries.

9. Former applications of the Bordeaux mixture upon the trees of this orchard appeared to possess little value in perfecting the crop this year, but all circumstances were not favorable to an accurate experiment regarding this point.

10. The early use of the copper-sulphate solution may be of value if orchards are uniformly and thoroughly sprayed with it. In our experimental orchard, with unsprayed trees as probable sources of infection, the value of such treatments has not been very marked.

11. London purple possesses no fungicidal properties.

12. Former applications of arsenites appear to have exerted no influence in suppressing insect ravages during the past season.

13. If only one substance is applied to apple orchards, it should generally be Paris green.

14. Spraying orchards in some cases increases the yield of fruit from practically nothing to a full crop, but in other cases the operation is followed by nearly negative results in this direction.

15. It is doubtless true that much of the failure of apple orchards to bear is due to the want of proper fertilization and cultivation.

16. The true cause of the formation of rusty apples is obscure, but the character of the season appears to influence the severity of the attack.

17. The Bordeaux mixture has a tendency to produce rusty fruit even when prepared according to the formula given on page 110.

18. The ferrocyanide of potassium test used in the manufacture of the Bordeaux mixture is not so satisfactory as was at first thought, for the mixture when so prepared may be injurious to the fruit

19. Munson has shown that Paris green possesses fungicidal properties.

20. Stinson has shown that fruit sprayed three times was larger than that sprayed twice, although the per cent. of scab on both lots was the same.

21. Paris green must be applied immediately after the blossoms fall in order to be most effective against the codlin moth.

22. Rust was very prevalent in Chautauqua county the past season, but apple growers, on the whole, are well satisfied with results obtained from spraying.

23. London purple is an unreliable insecticide in some cases.

24. The failures which have occurred may be due largely to the lateness or the hastiness of applications.

25. The leaf spot and the cracking of quinces may be controlled by the proper use of Bordeaux mixture.

26. Applications for the control of this disease need not be made so early as in the case of the apple-scab fungus.

27. The shot-hole fungus attacking plum and cherry foliage can be controlled by the use of Bordeaux mixture as described on page 128.

28. The fruit rot of plums and peaches can be checked by the use of the fungicides mentioned on page 129.

29. Some varieties of plums are more subject to the attacks of fungi than others.

30. Spraying plum foliage with the Bordeaux mixture thickens the leaves, but further measurements must be made to establish a rule.

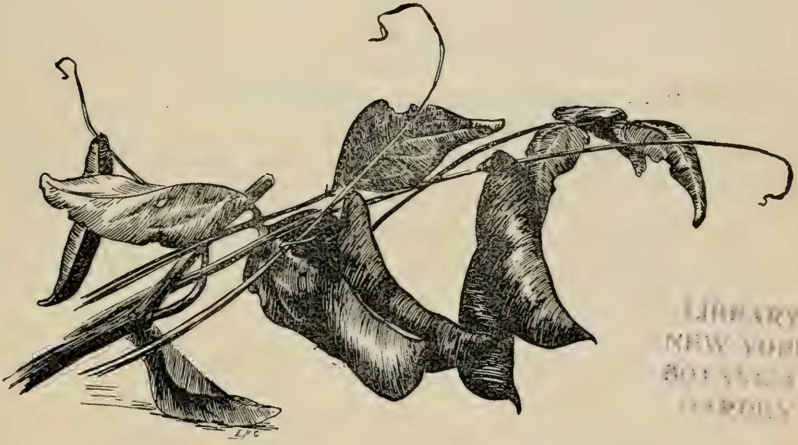
E. G. LODEMAN.

BULLETIN 87—April, 1895.

Cornell University—Agricultural Experiment Station.

HORTICULTURAL DIVISION.

The Dwarf Lima Beans.



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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

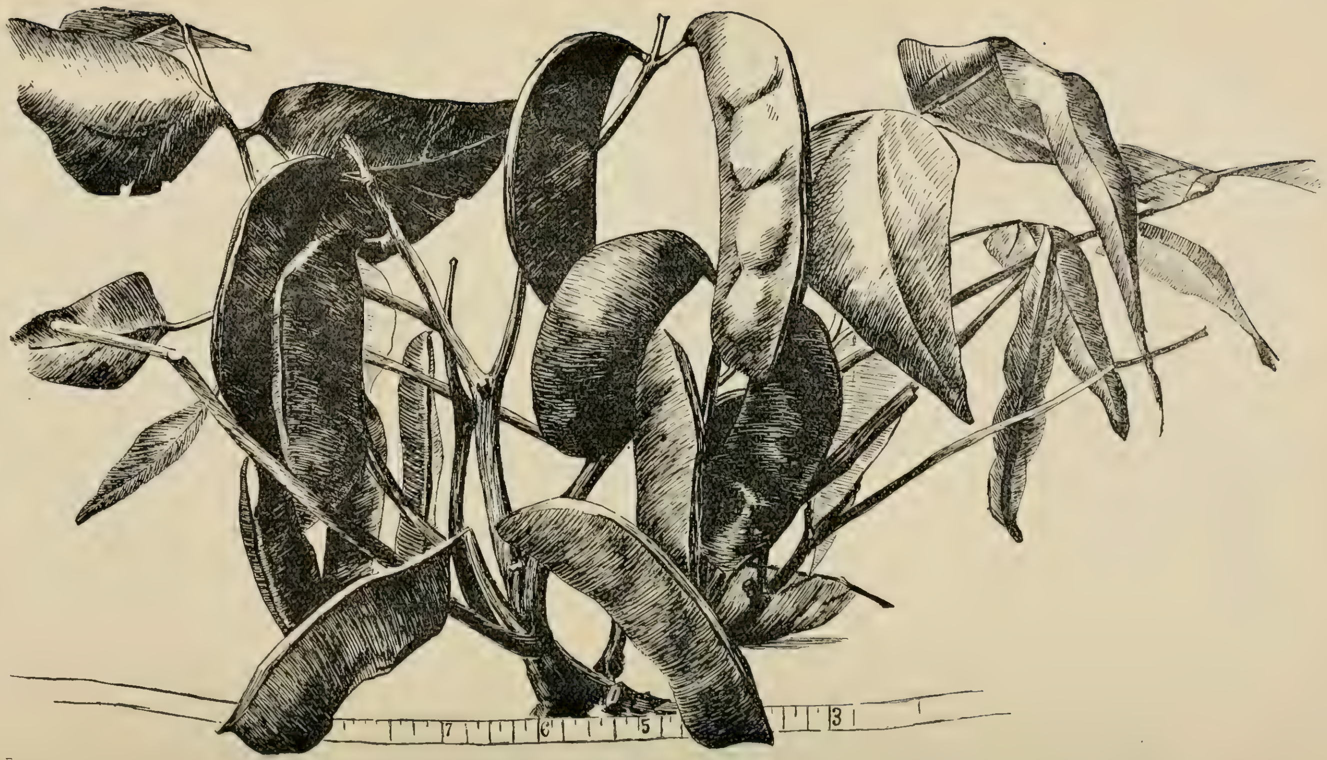
84. The Recent Apple Failures in Western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.

CORNELL UNIVERSITY,
ITHACA, N. Y., *April* 1, 1895.

The Honorable Commissioner of Agriculture, Albany:

SIR.— One of the most novel and interesting recent features of vegetable gardening is the sudden appearing of a number of dwarf or bush beans of the Lima bean type. The ordinary or pole Limas are an uncertain crop in many parts of western New York, and people are looking to these dwarf forms for varieties which are adapted to our seasons and which do not require the annoyance and expense of poling. We have made a careful study of them, and submit the account for publication under Section 87, Chapter 675, of the Laws of 1894.

L. H. BAILEY.



27. Thorburn or Kumerle Dwarf Lima. (Page 142.)

The Dwarf Lima Beans.

Beans of the dwarf Lima type have attracted much attention during the past few years, but there appears to be considerable confusion as to their merits and little positive knowledge of their botanical features. The writer began the study of this class of beans in 1889, when Kumerle and Henderson dwarf Limas were introduced, and the investigation has been continued until the present time. It was not until last year, however, that the whole subject was carefully gone over with a view of publication, in response to many inquiries for definite information respecting this interesting type of garden vegetables. Some unexpected results have followed this study, particularly in respect to the botanical affinities and the histories of the varieties.

In the first place, it should be said that the dwarf Lima beans constitute a new type of garden vegetables. They have all appeared in public within the last decade, and they are apparently nearly unknown in other countries, except as introductions from North America. Seedsmen and horticulturists often remark that when any very decided variety of plant is introduced, other varieties of the same general type are likely to at once appear. Gardeners will recall, amongst many other instances, the case of the large-leaf tomatoes, the Mikado, Turner Hybrid and Potato Leaf all appearing nearly simultaneously. This curious phenomenon has been forcibly stated by one of our leading seed experts,* as follows:

"Plants have inherent tendencies to variation which are developed and appear only after years of cultivation. Seedsmen receive every year scores of new potatoes raised from seed, and it is astonishing how much resemblance there is in the seedlings of any period of about three years. Thus, a few years ago we had the St. Patrick, Burbank and White Star, which, although distinct varieties and raised under very different circumstances, are certainly very similar to each other. Later we have appearing the Mayflower, Garfield, and many other similar sorts. And the appearance of any distinct variety is sure to be followed by others, which although raised from entirely different stock, are very similar to the first. The Favorite tomato is followed by the Optimus, Beauty, and a score or more of unnamed varieties raised in different localities and from different stock, but of comparatively little commercial value because so similar to the named sorts; but if any one of them had appeared a year or two earlier, it would have been regarded as of the greatest value. It is claimed that the hard-shelled Champion, or Kolb's Gem watermelon originated in Georgia in 1882, from a cross between Scaly Bark and Cuban Queen. It is quite distinct from any observed sort or cross appearing before that date, but I know of two unnamed sorts originating in 1882 — one in Illinois and the other in Florida — from different parentage, but practically identical with the Gem. The Minimum and American Wonder peas originated about the same time — the one in England, the other in America — and were a new type of evident value and importance, which, had they appeared among the thousands of new sorts raised before that time, would have been extensively propagated and sold; but these two named sorts are only two of many peas of that type which appeared at that time."

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* W. W. Tracy, of D. M. Ferry & Co., in Proc. Sixth Meeting Soc. Prom. Agr. Sci. 47 (1885).

There has been considerable speculation as to the cause of this singular synchronism, or the nearly simultaneous appearing of similar types. It was long a source of perplexity to me, and it is not yet wholly explicable, although these dwarf Lima beans, which we are about to study, offer some explanation of the question. These beans afford a remarkable instance of synchronistic variation. Henderson and Kumerle dwarf Limas were introduced in 1889, Burpee in 1890,* Jackson Wonder in 1891, and Barteldes in 1892 or 1893. The variety which is now called the Henderson was picked up twenty or more years ago by a negro, who found it growing along a roadside in Virginia. It was afterwards grown in various gardens, and about 1885 it fell into the hands of a seedman in Richmond. Henderson purchased the stock of it in 1887, grew it in 1888, and offered it to the general public in 1889. The introduction of Henderson's bean attracted the attention of Asa Palmer, of Kennett Square, Pennsylvania, who had also been growing a dwarf Lima. He called upon Burpee, the well-known seedsman of Philadelphia, described his variety, and left four beans for trial. These were planted in the test grounds and were found to be valuable. Mr. Palmer's entire stock was then purchased — comprising over an acre, which had been carefully inspected during the season — and Burpee Bush Lima was presented to the public in the spring of 1890. Now, Mr. Palmer's dwarf Lima originated in 1883, whilst Henderson's originated at least ten years earlier; and Mr. Palmer made his own variety public because he was attracted by Henderson's advertisement. In other words, the simultaneousness of these two varieties was only an apparent one. This is certainly true of many apparently simultaneous varieties. They have originated at widely different times and in different ways, and have been cultivated year after year, perhaps, in obscure places. When someone introduces a strange type, attention is directed to all similar varieties, and they are called into notice, in the same way that an unusual event in some locality is often followed by the recital of other similar events.

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* The statement in Annals of Horticulture for 1889 (p. 97) that Burpee Bush Bean was introduced in 1889, is an error. The dwarf Lima which Burpee offered that year was the Henderson.

Yet it is true that, speaking broadly, there is a general tendency in any species, and amongst closely related species, to vary in similar directions. The angular or cornered tomatoes of a generation ago are rapidly passing into the large round apple-shaped tomatoes, particularly in North America, where this evolution has progressed farther than elsewhere in the world. All varieties of potatoes are progressing towards seedlessness. There are reasons for these general onward movements of plants, which can not be explained here. All that need be said in explanation of this tendency is the fact that the beans tend to vary into bush or non-twining forms. We shall discover presently that these dwarf Lima beans are offshoots of two or three distinct species. We know that the original forms of these species were climbing plants. Now, this known tendency to the production of dwarf forms in these three species or types of so-called Lima beans, affords an excellent illustration of how the common field and garden beans must have originated. The common bean, both in its pole and bush form, is wholly unknown in a wild state. Even its native country is undetermined, although there is the strongest circumstantial evidence that the species is Amercian. Linnæus, over a hundred years ago, described two species of the garden kidney bean, *Phaseolus* (pronounced Fasé-o-lus) *vulgaris*, the pole bean, and *Phaseolus nanus*, the bush bean. It is now generally agreed that these two forms are horticultural modifications of one original type. But which was the original form, the twiner or the bush form? If all the so-called bush Limas are known to have come from twining plants, there is, thereby, the strongest reason for supposing that the common bush beans originated from the twiners, a conclusion which is also supported by much other evidence.

The reader is now anxious to know just how these dwarf Lima beans originated. They appeared in the same way that nearly all new varieties of plants originate: they were found growing amongst plants of common and well-known varieties. A single plant, a "sport," was first observed in some cases, and in others several original plants were discovered. The Kumerle or Thorburn Dwarf Lima originated from occasional dwarf forms of the Challenger Pole Lima which J. W. Kumerle, of Newark, New Jersey, found growing in his field. The Henderson, as we have seen, was a chance dwarf picked up in Virginia. The Burpee came from a single plant of the Large White Lima. Mr. Palmer, with whom it originated, had his entire crop of Limas destroyed by cut-worms in 1883. He went over his field to remove the poles before fitting the land for other uses, but he found one little plant, about ten inches high, which had been cut off about an inch above the ground, but which had re-rooted. It bore three pods, each containing one seed. These three seeds were planted in 1884, and two of the plants were dwarf, like the parent. By discarding all plants which had a tendency to climb, in succeeding crops, the Burpee Bush Lima, as we now have it, was developed.

The singular Barteldes Bush Lima came from Colorado and is a similar dwarf sport of the old White Spanish or Dutch Runner bean. Barteldes received about a peck of the seed and introduced it sparingly. It attracted very little attention, and as the following season was dry, Barteldes himself failed to get a crop, and the variety was lost to the trade. Just why these bush forms should appear in these instances, we must ask mother nature, and it is possible that she will never be persuaded to give an explicit reply. We hear much about the scientific origination of varieties, but as a matter of fact, the science of the horticulturist is exercised much more in determining when a given form is valuable and in the subsequent breeding or selection of it, than in any power which he possesses over the original genesis of novel types. Certainly, with the dwarf Lima beans, the horticulturist owes less thanks to science than to good luck and cut-worms.

Before proceeding to an account of the actual merits of these dwarf Lima beans, I must still further bewilder my reader with a discussion of the botany of them. So far as we can determine from any literature yet written, these beans are simply dwarf forms of various Limas. But this is not sufficiently explicit. There are three well-marked types or groups of Limas in cultivation in this country, two of which have been considered by many botanists to represent distinct species. Linnæus, nearly a hundred and fifty years ago, described two species of beans, which modern botanists consider to be the parents of the so-called Lima beans of gardens. Now, the dwarf Lima beans have sprung from each of the three different types of pole Limas, and one of them is a semi-perennial plant and is an offshoot of the same species which gives us the Scarlet Runner, Painted Lady and White Dutch Runner. The botanical types from which these so-called dwarf Limas have sprung may be arranged as follows:

I. *Phaseolus lunatus*, Linn, (Sp. Pl. 724, 1753). Carolina, Sieva, Sewee, Saba, Sivy, Civet, Sky, West Indian and Butter Beans. Bushel Bean of early American writers. *Phaseolus bipunctatus*, Jacquin, Hort. Vind. i. p. 44. t. 100 (1770) is commonly referred to Linnæus' *P. lunatus*, and it is probably an outlying form of it, but it is not in cultivation in this country, so far as I know. It differs from our Sievas by its long leaves, different pod, and conspicuous hairiness.

Dwarfs.—Jackson (Jackson Wonder); Henderson; Northrup, Braslan and Goodwin Dwarf Lima; Dwarf Carolina.

I A. *Phaseolus lunatus* var. *macrocarpus*, Bentham (Flora Brazil. xv. i. 181, 1862). *P. inamœnus*, Linn. Sp. Pl. 724; Jacq. Hort. Vind. i. p. 27, t. 66. Other specific names which seem to belong here are *P. Limensis*, *P. saccharatus*, *P. fœcundus*, *P. latisiliquus*, Macfayden, Fl. Jamaica (1837; *P. puberulus*, HBK. Nov. Gen. vi. 451; *P. Xuarezii*, Zucc. in D C. Prodr. ii. 393.

This is the Lima bean of American horticultural literature. We may distinguish two leading types:

1. Potato Limas, characterized by tumid or nearly spherical beans.
   Dwarf.—Thorburn, Kumerle or Dreer.
2. Flat or large Limas, with very large and flat veiny seeds, a tall growth and late maturity.
   Dwarf.—Burpee.

II. *Phaseolus multiflorus*, Willd. (Sp. Pl. iii. 1030). *P. coccineus*, Lam. Encyc. iii. 70, not of Linnæus. Scarlet Runner, Painted Lady, White Dutch Runner, and Spanish beans.
Dwarf.—Barteldes.

The above classification accounts for all the so-called dwarf Limas, seven in number, with which I have met. It will aid us to understand the subject if we briefly stretch the history and distinguishing marks of these various types.

I. The Sieva or Carolina bean is a small and slender grower as compared with the large Limas, early and hardy, truly annual, with thin short and broad (ovate-pointed) leaflets, numerous, small papery pods which are much curved on the back and provided with a long upward point or tip and which split open and twist when ripe, discharging the seeds; beans small and flat, white, brown or variously marked with red. The beans are shown at Nos. 1, 2 and 3 in Fig. 24, and the foliage and pods on the cover illustration and in Figs. 25 and 26. This type is always distinguishable from the large Limas with the greatest ease, and is really as distinct from that type as *Phaseolus multiflorus* is. I am inclined to believe that it will eventually be discovered to have had a different specific origin from the Limas. Always smaller than the true Limas, it also has a well-known tendency to vary into small or bush forms, as in the Dwarf Carolina, a half dwarf which has been well known for many years, and this tendency is apparently much more strongly developed than in the Limas.

Linnæus believed that this bean came from Bengal, but it is now understood to be South American, although it is not certainly known in a wild state. It was early known in North America. Lawson, in his voyage to Carolina in 1700–8, mentions Bushel Beans as a spontaneous kind. Gay and Trumbull* guess that this may have been a form of *Phaseolus multiflorus*, or Scarlet Runner, but this is very improbable. M'Mahon mentions it in 1806 in his "American Gardener's Calendar:" "What is commonly called the Carolina bean is only a small and early variety of Lima bean." Deane also speaks of it in New England in 1797 as "being cultivated in this climate of late to advantage," * but he does not mention the Lima bean. Gardiner and Hepburn, in the "American Gardener" 1804, do not mention it, although the Lima is recorded. The early cultivation of the plant amongst the Indians and settlers of Carolina, no doubt gave it the name of Carolina bean. The origin of the various other names which it has received is not so easily determined, but since the plant is evidently of tropical origin and is often known in early writings as the West Indian bean, I suppose that its name Saba comes from the island Saba in the West Indies; and it is not unlikely that Sieva and Sewee are derivations from the same name. The word Civet, which is possibly of European origin, is probably derived from the use of the beans in the dish known as civit stew. †

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* *Amer. Journ. Sci.* xxvi, 133.

IA. The Lima bean is distinguished from the Sieva by its tall growth, lateness, greater susceptibility to cold, perennial in tropical climates, large thick often ovate-lanceolate leaflets, and fewer thick fleshy straight (or sometimes laterally curved) pods without a prominent point and not readily splitting open at maturity; seeds much larger, white, red, black or speckled. Dwarf forms of the Lima are shown in Figs. 27, 28 and 29, and in Nos. 4, 5 and 6 of Fig. 24.

Linnæus thought that this bean came from Africa, but it is now well determined that it is South America. Unmistakable seed have been taken from Peruvian tombs and the plant has been found wild in Brazil. I do not know the origin of the word Lima, which,

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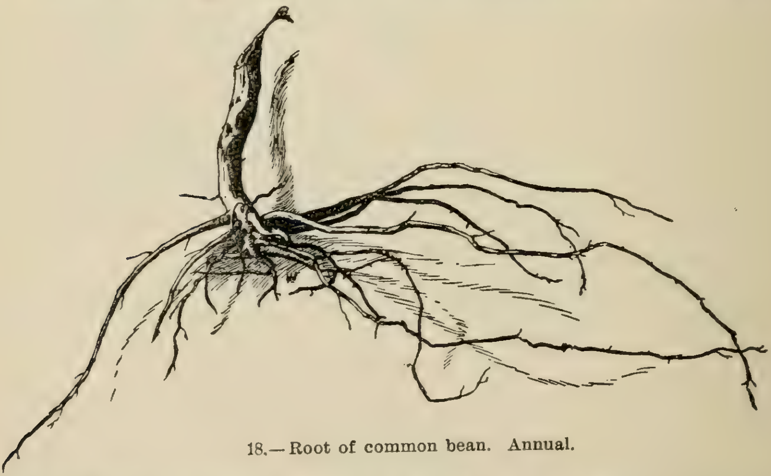
* *New England Farmer, 2d ed.*, 23.

† I have made a careful search for the origin of the names of this bean. Professor Massey, of the North Carolina Experiment Station, to whom I addressed an inquiry, writes as follows:

"I am sorry that I am unable to help you in the search for the origin of the name Sieva, or Sewee, as applied to the small-seeded Lima bean. I have often wondered where the name came from and have looked up all I can find on the subject. The only thing that ever seemed like an explanation was that given by an old man in South Carolina, who thought it was originally the 'Seaweed' bean, indicating that the seeds had drifted ashore in seaweed. I can find no foundation for this notion, and simply give it for what it is worth. I know of no local name of any section or district from which it could have been derived. It may possibly be a Cherokee name, for their names very commonly ended with double e, and they always give the accent on this last syllable."

according to De Candolle, has been used "since the beginning of the century," but I suppose that it comes from the city Lima in Peru. The name has been commonly employed by writers in America from 1804 to the present time, and it is probably of still earlier origin. The two forms, the round-seeded or potato Lima, and the large flat Lima, were early known and described in Europe, the latter, and evidently the former, as early as Lobel, 1591.

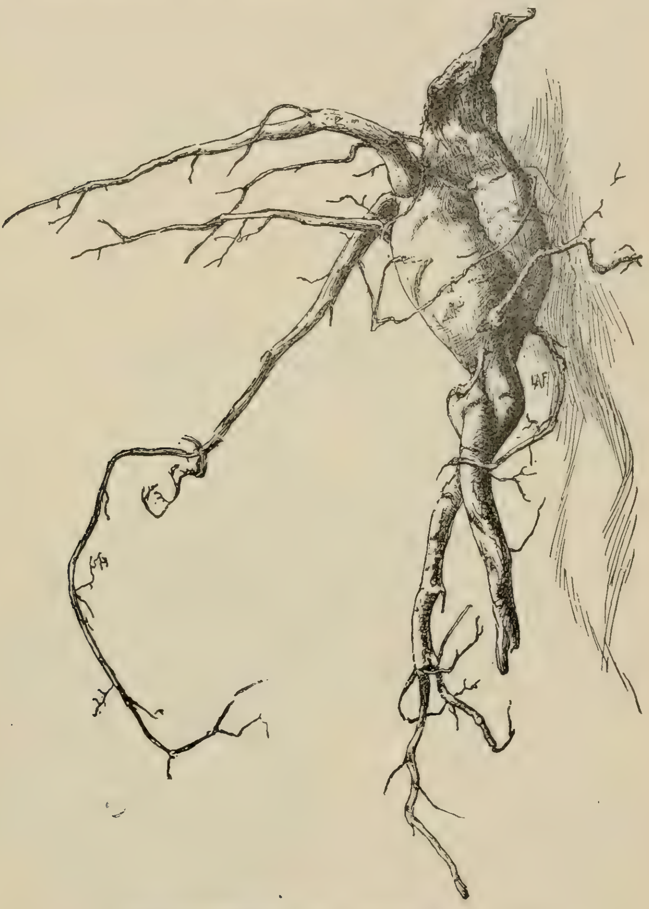
II. The Scarlet Runner and Dutch Runner type of beans (*Phaseolus multiflorus*) is probably native to Mexico, or perhaps of regions to the southward. It is cultivated mostly as an ornamental plant in this country, and yet the young pods and the ripe beans are excellent for the table. There are only two varieties—mentioned above—in common cultivation in this country. It appears to be in greater favor as an esculent amongst the Mexicans. In 1891 a single bean was sent me from Colorado as "Mexican bean." The plant, as we grew it in our forcing houses, was apparently identical with the White Dutch Runner, except that its tuberous root was larger than any which I had seen elsewhere, — for all these beans are perennials. We were unable to induce the plant to fruit, although the flowers were hand pollinated. A subsequent experience which I had with the western form of this species was in the spring of 1894, when I grew the Melde Perennial and Irvine Hybrid Perennial, which were distributed for trial by the California Experiment Station in 1893 and 1894. It is supposed that the latter is a hybrid between the Lima and Painted Lady



18.—Root of common bean. Annual.

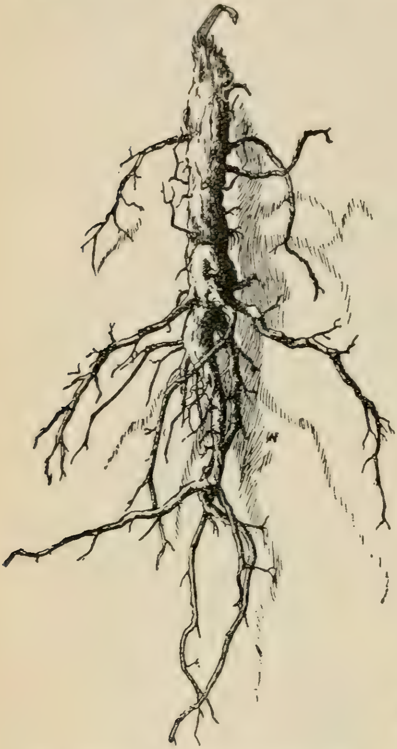
beans, but I can find no evidence of hybridity, and I have no hesitation in calling it a straightforward variety of *Phaseolus multiflorus.*

But the most marked type of this bean which I know is the Barteldes Bush Lima, which is as completely bush form as the common field bean, and which has so far departed from the character of its parent that it is almost or quite annual in the growth of its root. The illustrations explain this curious evolution towards an annual root. Fig. 18 shows the root of a common bush bean (Sion House). The root lacks wholly any tap root, and the fibres are hard and woody and die completely when the beans mature. Fig. 19 is a root of one of the most perennial types of Barteldes Bush Lima, and it shows the fleshy tap-rooted character of the root system. This

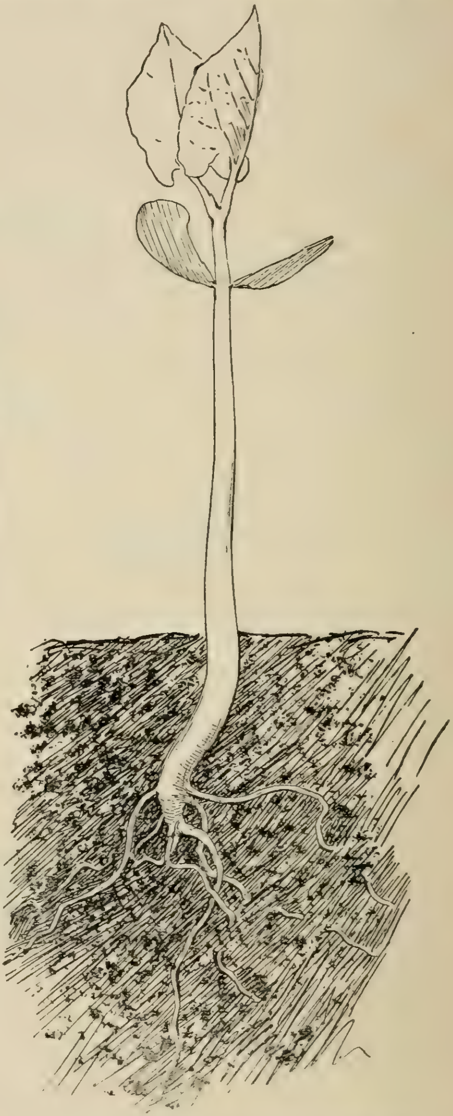


19.— Fleshy or perennial root of Barteldes Bush Lima.

root remains live and fleshy after the tops are killed by frost, and it would no doubt grow the following spring if not killed by the winter. From the same packet, some seeds of Barteldes Bush Lima produce roots which are almost perfectly fibrous and which gradually die after the top has been cut short by frost, as in Fig. 20. This root is imperfectly annual; and I have no doubt that if attention were given to the matter, a truly annual bean could be developed from this type in a comparatively short time.

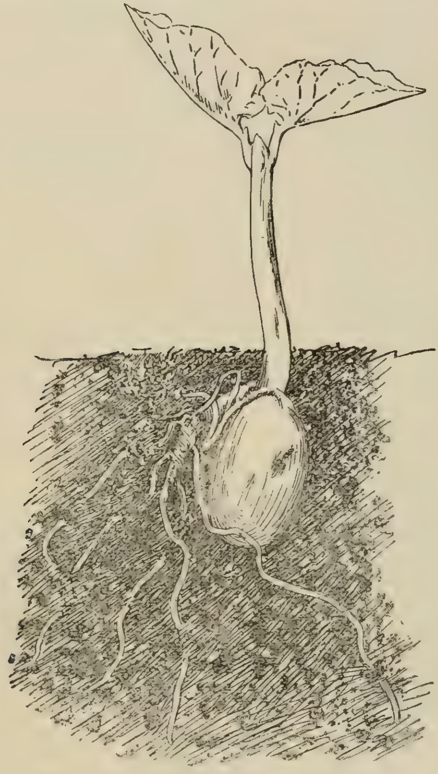


20.—Fibrous plur-annual root of Barteldes Bush Lima.



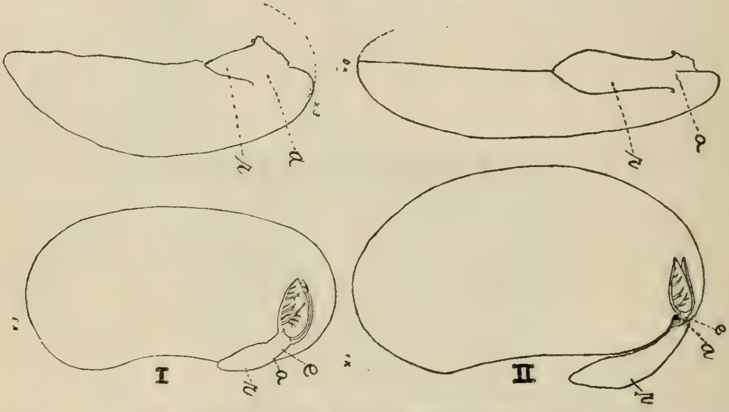
21.—Germination of the common bush bean.

Another peculiarity of this Barteldes bean is that the cotyledons, or halves of the bean, remain below ground when the seed germinates. This is a peculiarity of all forms of *Phaseolus multiflorus*, so far as I know. Fig. 21 shows the familiar germination of the common bean with the seed halves appearing above ground at *a. a.* Fig. 22 illustrates the peculiar behavior of the Barteldes in keeping the seed halves below ground. The botanist will be curious to know how the vital parts of the seed look, when they are dormant. Fig. 23 shows diagrams of a seed of Barteldes (I) and Burpee Bush Lima (II). The two upper diagrams show a seed split in two, so that the observer is looking at the inside face of one of the cotyledons or seed halves. The embryo is seen at the left. At *r* is shown the radicle or root portion, at *e* the stem portion, and at *a* the junction of the two. At the tip of the embryo are the two little bodies which are to become the first true leaves of the plantlet. It will be noticed that the radicle of I. — the Barteldes — is short, whilst the stem portion is long as if in readiness to elevate the leaves into the air, leaving the cotyledons or seed halves below. This stem portion *e*, therefore, is the epicotyl or that part of the



22.—Germination of Barteldes Bush Lima.

stem which stands betwixt the cotyledons and the true leaves, whilst the hypocotyl, or that portion of the stem below the cotyledons is obsolete. In II, however,—the Burpee—the stem portion is very short, and the root portion is long and is partly comprised of the hypocotyl, which, by elongating, elevates the seed halves into the air. If, now, the outer covering or skin is removed, and the bean is placed on its back, we see the parts as shown in the lower diagram. Here, again, only one-half of the bean is shown. These views emphasize the long radicle of the Burpee (on the left) and the very short radicle of the Barteldes (on the right).



23.—Structure of the Lima and Multiflorus beans.

I have finally arrived at the point of saying something about the economic value of these dwarf Lima beans. I am convinced that these beans, as a class, are very valuable. Their great merit is earliness. They are from two weeks to a month earlier than the tall varieties from which they came. Their productiveness has not been reduced in proportion to the reduction in size of the plants, so that I believe that it is possible, in the north to secure greater total yield per acre from the dwarfs than from the pole varieties, seeing that the plants require less room. They are also much cheaper to grow. They require no poles. In central New York, the tall Lima beans are always a precarious crop, on account of their lateness and the liability of being injured by midsummer droughts at the time when the pods are setting. The earliest varieties of these dwarf Limas are those which are derived from the Sieva type, as Henderson and Jackson. The following field notes of the varieties indicate our experience with them :*

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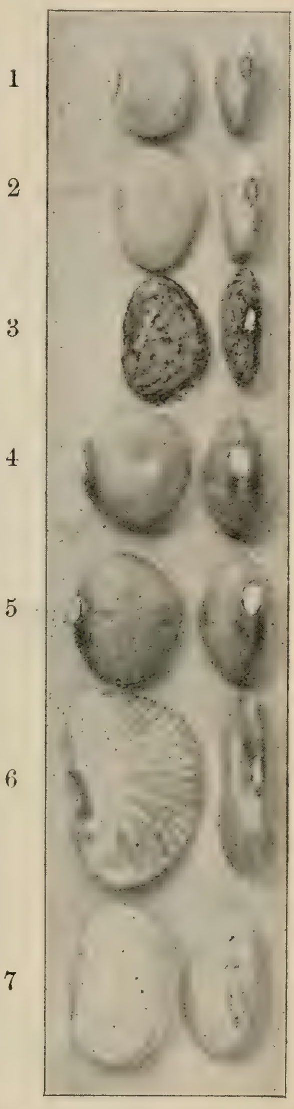
* The reader will also find a good account of two or three of the dwarf Limas in 2d Rep. Kans. Exp. Sta. 150, with illustrations (1889).

Henderson Bush Lima (No. 2, Fig. 24; Fig. 25).—Very dwarf, with only an occasional plant producing a feeble tendency towards a climbing stem, requiring no more space than field beans; plant compact, bushy, very productive and continuing long in bearing; very early; beans small, flat, clear white; quality good. A patch planted on the 6th of June last year was bearing well the second week in August, notwithstanding the almost unprecedented drought. An occasional plant produced speckled beans. This seems to be the best variety for earliness, and its great productiveness and habit of long bearing are additional recommendations. The pods also escape the mildew, which is often serious upon the late, thick-podded sorts. Whilst good in quality, it lacks the buttery and rich quality of the true Limas.

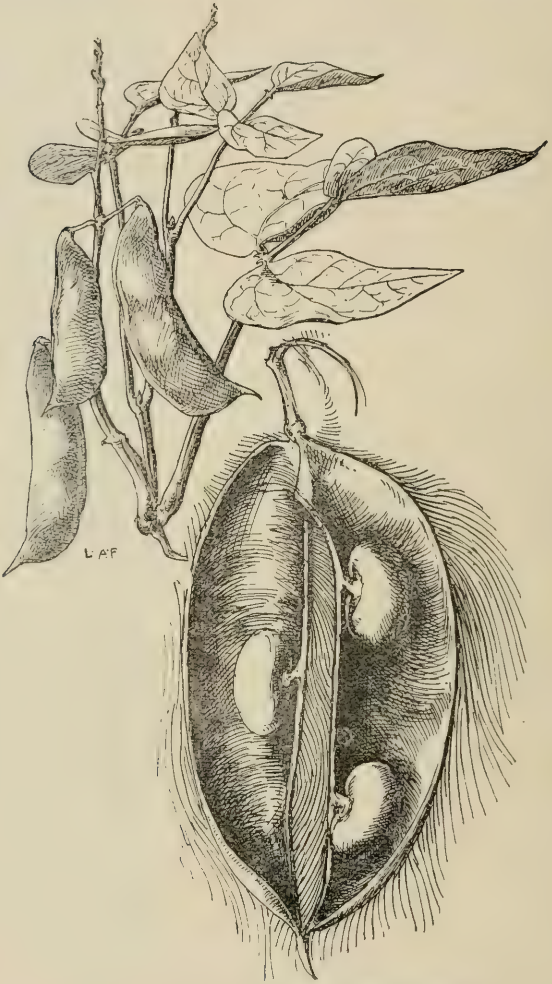
Jackson (No. 3, Fig. 24; Fig. 26).—This variety, commonly known as Jackson's Wonder, differs from the Henderson in having brown-speckled beans, and in a less dwarf and compact habit, and it is possibly a little later. In productiveness it even excels the Henderson. All of the vines in our plantations have made a diffuse, sprawling growth, and many of them make twining shoots two feet long. On account of this diffuse habit and the color of the beans, it has seemed to us to be less desirable than some other varieties. Its great productiveness, however, is a strong recommendation.



24.—Dwarf Limas (nat. size). 1. Sieva; 2. Henderson; 3. Jackson; 4. Thorburn; 5. Dreer; 6. Burpee; 7. Barteldes.

Northrup, Braslan and Goodwin Dwarf Lima I know little about. I have tried it only a single season in a small way. It is apparently much like the former varieties, but the beans are uniformly dun colored.

Thorburn or Kumerle Dwarf Lima (No. 4, Fig. 24; Fig. 27, p. 82).— Very bushy and dwarf bean, with no tendency to climb; leaflets thick, long ovate or lance ovate, more or less deltoid at the base; pods large and thick; beans white, tumid, of very excellent quality; rather late, and moderately productive. With us seeds planted June 6th began to give edible beans the first and second weeks in September. The plants are stout, 10 to 18 inches high. Many persons consider the potato Limas — of which this is a dwarf type — to be superior to the large white Lima in quality. *Dreer*



25.—Henderson Bush Lima (open pod nearly natural size).

Bush Lima (No. 5, Fig. 24) is the same, having been introduced from Mr. Kumerle's stock.

Burpee Bush Lima (No. 6, Fig. 24; Figs. 28 and 29).—A true Lima bean. Very dwarf, although somewhat taller and wider growing than Thorburn (16 to 30 inches high), with little or no tendency to climb; leaflets broadly ovate; pods large and thick; beans as large as pole Lima, very flat and veiny, of the highest quality; season medium to late, beginning to ripen about two or three weeks after the Henderson; productive. Upon our grounds this has been the best single variety of dwarf Lima.

26.—Jackson Dwarf Lima.

With us last year, the Burpee was rather earlier than the Thorburn, although there is little difference in season between these two types. The following notes on the season of the three types of dwarf Limas were made in Massachusetts in 1892: * "May 25, sowed Henderson, Dreer and Burpee Bush Limas. Picked Henderson August 10; Dreer August 23; Burpee August 24. Summary: Henderson, early, small but very productive; Dreer, medium sized but very fine flavored; Burpee, very large and more productive than Dreer." With us, the Burpee has been more productive than the Thorburn type, but others have had contrary results. It is probable that there is no constant difference between the two in productiveness.

28.—Burpee Bush Lima.

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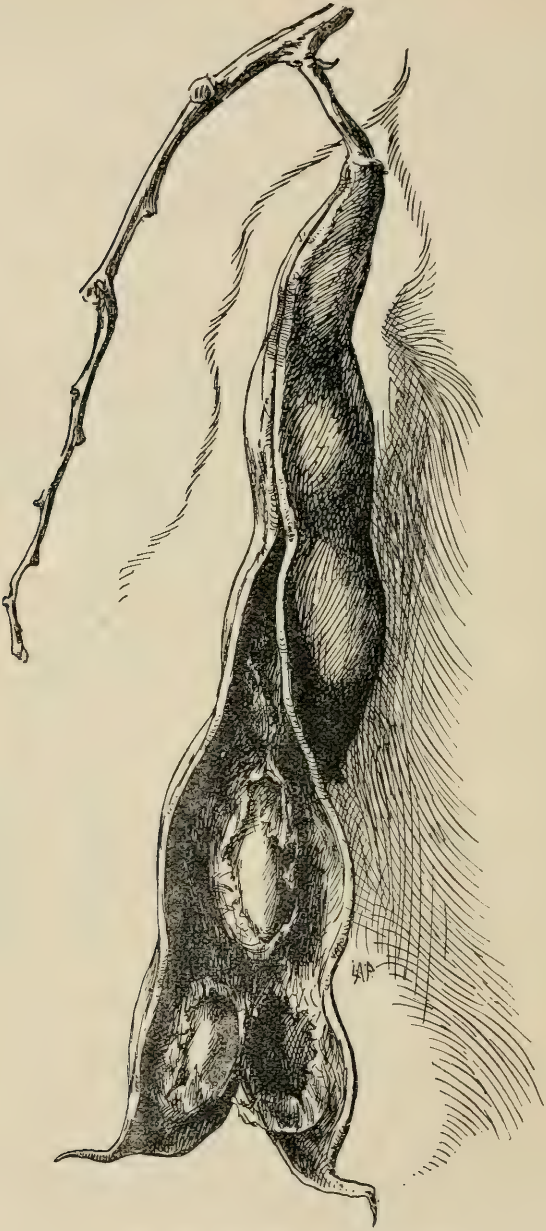
* Alfred G. Clark, *Amer. Gard.* xi v, 110.

Barteldes Bush Lima (No. 7, Fig. 24; Figs. 30 and 31.) — A small bushy plant of rather weak and sprawling habit, about the size of plants of the field bean; pods 5 or 6 inches long, more or less depressed between the seeds, containing three or four large, oblong and plump white beans which are of good quality. It is very late at Ithaca, maturing only a few of the earliest pods before frost, and is, therefore, apparently of little account for this latitude. It appears to be unproductive also.

29.—Burpee Bush Lima.

30.—Barteldes Bush Lima (natural size).

We have endeavored to force the Henderson and Burpee under glass. The Henderson has some promise, although it is doubtful if it will ever pay to force any other bean than the string or snap bean. But we will try it again. Burpee ran to vine, and was unproductive. Whilst it is generally a complete dwarf in the field, it runs five to seven feet high in the house.



31.—Barteldes Bush Lima (natural size).

The following account of the dwarf Limas, from the gardener's standpoint, is contributed for this occasion by T. Grenier, of La

Salle, Niagara county, a well-known and careful horticulturist and author:

"I am acquainted only with the three kinds of bush Lima, which are now catalogued by every seedsman, viz.: Henderson, Dreer and Burpee. The dwarf or bush character of all these three seems to be well fixed, and only in the Burpee do I find an occasional reversion to the original twining form. With the exception of this change in habit of growth, the bush Limas have all the advantages and faults of the original variety. Henderson possesses all the characteristics of the ordinary pole Sieva; Dreer, those of the ordinary Dreer Pole Lima; and Burpee, those of the old Large Lima.

"If I lived in a locality with seasons too short for the development of the large Lima beans, I would surely plant Henderson, which is as early, as productive, but also as small in foliage and individual seed as the pole Sieva. This bush Sieva is as easily grown as any ordinary dwarf bean, and will do well on any ordinary good corn land. I can see no more reason to grow the pole form of the Sieva than to seek for and grow the pole form of the Early Valentine, or any of our common snap beans, except perhaps for ornament, variety or curiosity. The plants are usually so well loaded with pods that one can gather the latter by handfuls. On the other hand, the single beans are small, and not equal in quality to the larger Limas. The dry bean also is easily grown, since the pods shed water well, and protect the seed from becoming spotted.

"Dreer Bush Lima equals Dreer Improved Pole Lima in quality, being superior in this respect to all other beans which I have ever grown. Its habit of growth, however, is far from being ideal. The pods grow closely together near the ground, and are in danger of becoming badly soiled, and of rotting long before the beans are fit for use. It will need improvement in this respect long before it will ever become popular, notwithstanding its high quality.

"Burpee Bush Lima leaves nothing to be desired in form of plant except breeding out the slight tendency reverting to the climbing habit. The plants are reasonably productive, the pods filled with from one to four very large beans, and the quality of the latter good enough for anybody. The ground should be rich and warm, and kept well cultivated. A good crop can then be grown even in a pretty dry season. But this is applicable to Pole Limas with equal force.

"For some years I have been looking for accidental crosses between these bush Limas, and for the purpose of supplying the most favorable conditions for their production, have planted large patches with mixed seed, but thus far have failed to find a single cross."

REVIEW.

The dwarf or bush forms of the Lima beans are, as a class acquisitions to the vegetable garden. They belong to two distinct species, *Phaseolus lunatus* and *P. multiflorus.* The single variety derived from the latter species—the Barteldes—seems to have little to recommend it for cultivation in New York. The dwarf offspring of *Phaseolus lunatus* are of three general types: 1. The Sieva dwarfs, which are the earliest and most productive and of which the most serviceable variety appears to be the Henderson. 2. The potato Lima dwarfs, represented by the Thorburn or Dreer, which is of the highest quality, and in all ways desirable. 3. The large Lima dwarf, the Burpee, which has been the leading single variety upon our own grounds, on account of the large size and high quality of its beans, and it is evidently as well adapted to general field culture as the earlier or smaller seeded varieties. All these dwarf Limas—Henderson, Jackson, Thorburn and Burpee—are worth growing either for home or market.

L. H. BAILEY.

VEGETABLE GARDENING PUBLICATIONS OF CORNELL UNIVERSITY EXPERIMENT STATION.

Bulletins which are marked with an asterisk are out of print. Articles which are published in miscellaneous bulletins, along with other matter, are inclosed in parenthesis.

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* Bulletin 7 (1889). On the Influences of Certain Conditions on the Sprouting of Seeds.

*——10 (1889). Tomatoes.

*——15 (1889). (The Onion Mould. Prevention of Potato Rot. A Point in the Cultivation of Root Crops. The Orange Melon. Influence of Soil upon Peas. The Influence of the Depth of Transplanting on Heading of Cabbages. Influence of Depth of Sowing on Seed Tests. Do old Seeds of Cucurbits give Shorter Vines than Recent Seeds? Tests of Patent Germinator.)

*——21 (1890). Tomatoes.

*——25 (1890). (The effect of removing Tassels on the Prolificacy of Corn. The Forcing of Beans. Influence of Latitude upon Potatoes. The Influence of the Depth of Transplanting upon the Heading of Cabbages. The Paper Flower Pot. Experiences in Crossing Cucurbits.)

*——26 (1891). Experiences with Egg Plants.

*——28 (1891). Experiments in the Forcing of Tomatoes.

——30 (1891). Some Preliminary Studies of the Influence of the Electric Arc Light upon Greenhouse Plants.

*——31 (1891). Forcing of English Cucumbers.

——32 (1891). Notes of Tomatoes.

*——37 (1891). (Physalis, or Husk Tomato. Pepino. Chorogi. Spanish Salsify. The Influence of the Depth of Transplanting upon the Heading of Cabbages.)

——40 (1892). Removing Tassels from Corn.

——41 (1892). On the Comparative Methods of Steam and Hot Water for Greenhouse Heating.

——42 (1892). Second Report upon Electro-Horticulture.

——43 (1893). Some Troubles of Winter Tomatoes.

*——45 (1892). Tomatoes.

——49 (1892). (Note on the Cercospora of Celery Blight. Corn-Detasseling Experiment. A new Maize and its Behavior under Cultivation. Behavior of Some Egg Plant Crosses. The Wild Potato of the Mexican Region. Do Fertilizers affect the Quality of Tomatoes? Substitute for Glass in Greenhouse Roofs.)

——53 (1893). Œdema of the Tomato.

——55 (1893). Greenhouse Notes.

——61 (1893). (A New Food Plant,—*Stachy's Floridana.* The Mole Plant-Garden Docks. Recent Varieties of Tomatoes. Tomato. Potato Grafts. A Potato Preserver.)

*——67 (1894). Some Recent Chinese Vegetables.

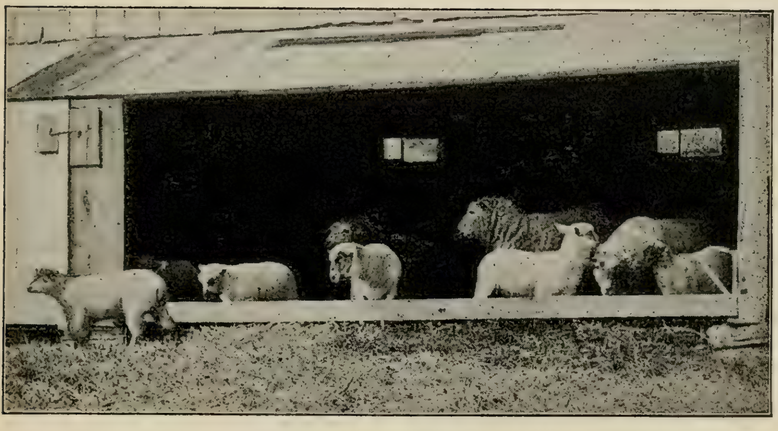
——78 (1894). The Cabbage Root Maggot, with notes on the Onion Maggot and Allied Insects.

BULLETIN 88 — April, 1895.

Cornell University—Agricultural Experiment Station.

AGRICULTURAL DIVISION.

EARLY LAMB RAISING.



By G. C. Watson.

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BULLETINS OF 1895.

84. The Recent Apple Failures in Western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.

Early Lamb Raising.

During the last three years experiments have been made to compare the merits of Shropshires and Horned Dorset sheep as breeds to produce "Hot house" or winter lambs. In the summer of 1891, the College of Agriculture and the Experiment Station owned but few sheep suitable for this trial, but it was thought best to begin the test with the available number and continue it through a number of years. Additions were to be made to the flock as opportunity offered and suitable quarters could be provided. In carrying out this test, particular reference has been given to the growth of grade lambs of these two breeds for the reason that the great majority of early lambs sent to the New York market are a cross of thoroughbred males on grade merino ewes. These ewes as bought or bred by the early lamb raiser have more or less blood of the improved mutton breeds, but still not enough to place them in any class other than grade merinos. In this connection it may be of interest to note the development of the merino sheep and the causes which made this breed a favorite for so many years.

As the great improvement of the merino was made by American breeders, they became admirably adapted to the climate and to the conditions under which the farmer of the Middle and New England states kept this class of stock.

The ability of the American merino to thrive on rather scanty pastures, the bleak hillsides and the half cleared fields has been a potent factor in subduing and improving much land that would otherwise have remained unproductive. These sheep have done a most excellent service for the American farmer and with a greater profit for the investment and labor bestowed than could have been obtained by any other breed at the time these improvements were made. This together with the reluctance of the sheep owners to give up that which has served them well has kept the merino sheep in the State for a number of years at very little or even no profit.

In the trials made in raising early lambs from merino or grade merino ewes it has been found that these sheep respond quickly in milk production to extra care and food and that they are well adapted for the purpose of early lamb raising.

Formerly merino sheep were kept with great profit for the production of wool alone, but with the great decline in the value of wool during the last few years, it became necessary for the sheep owners to dispose of them, or in some way so conduct the breeding and feeding that the meat product would equal or exceed that of the wool in value. Those who found it necessary to exchange the wool breed for some of the larger so-called middle breeds learned that the methods pursued with the merinos profitably would not give satisfactory returns with these English mutton breeds; the business had to be learned anew and frequently discouragement instead of success was the result which eventually led to the abandonment of sheep husbandry.

While the merinos would thrive in large flocks on rather indifferent pasture, providing it was not too wet during the summer dry feed and a suitable grain ration for the winter; it was soon found that the distinctively mutton breeds would not produce as desirable mutton on this food as the same breeds produce in England, where succulent food is fed throughout the year. It is now generally admitted that the best flavored, juicy mutton can not be produced by the food and care heretofore given by the American farmer to merinos. The consequent failures and discouragements have led sheep owners to produce a product not before attempted, early lambs.

The sheep owners throughout the State have pursued somewhat different courses in striving to produce the best product of this kind, and without doubt the method adopted by this Station will differ from those of many successful early lamb raisers.

Since a few ewes have been purchased each year since the season of 1891, it has been the custom to sell each year nearly all of those purchased the year before, retaining only a few of the best, those that raised the best lambs. In making this selection it has been found that the ewes that raised the best lambs, were the best milkers, and have been the ones as a rule that bred the earliest. In studying closely the records of all the ewes, the thoroughbreds as well as the grades, this fact has been clearly brought out, that there is a close connection between early breeding and great milk production. A great difficulty met with in raising lambs for the early market is to get the ewes to breed early. With ordinary precaution a few ewes of almost any flock that is at all suited for this purpose, will breed early and will fatten good lambs, but when early lamb raising is undertaken on a somewhat extensive scale, it is desirable to have a considerable number of ewes lamb about the same time, in order that one or more pens of ewes may be fed the same ration. If the lambs are all dropped within a short period the labor of caring for them will be much less than if they are dropped throughout a long period. In feeding all classes of stock it is desirable to have the animals that are fed together as uniform as possible and particularly is this essential in lamb raising. Whenever the ewes go into winter quarters in good flesh, very little or no grain and but few roots should be fed before lambing time ; this will enable the owner to carry the ewes through a critical period with less trouble than if grain and roots are fed liberally before the lambs are born. Whenever grain and roots are fed in considerable quantities to ewes before lambing, those ewes that are heavy milkers will give the owners more or less trouble on account of their udders becoming hard and inflamed from an undue secretion of milk. Of course this means that the best ewes are likely to be injured and a loss entailed which can not be afforded, particularly as the remedy is so simple. As the ewes recover from lambing, grain may be fed in small quantities at first but increased as fast as the condition and character of the ewes will safely permit. The best results have been obtained, everything considered, in feeding grain as described and forcing the ewes to their utmost from a period of four to eight weeks after lambing. At this time extra grain and care will bring greater returns than any other time during the year ; the profit derived from this increased flow of milk is not directly proportional to the total yield. A little extra food may bring the lamb into prime condition and cause it to sell for the highest market price, while the same lamb without this increased nourishment would be only in fair condition and sell in the market for not more than two-thirds the price of prime lambs.

It is of the utmost importance that the lambs be well fattened No matter how large and thrifty a lamb may be, it will not sell for the highest price if it is not fat.

During the time that the ewes are being forced to their greatest capacity for milk, the lambs should receive equally as careful attention in the way of inducing them to eat as much food as possible.

It has been found that these lambs will consume more grain food if a change is frequently made so that a varietly is offered them. In changing this food, it has been observed that the lambs will eat a certain kind of grain with considerable relish for a day or two and then seem to tire of it and consequently consume less; as soon or even before this stage has been reached, if a change in the grain ration is made, it has been found that the lambs will consume a large amount of grain without loss of appetite.

A little sugar sprinkled on ground feed will help materially to teach the lambs to eat, and in order to still further facilitate this the grain should be so placed that it is within easy reach of the lambs at all times and where it can not be disturbed by the ewes. It will not take the feeder long to ascertain what kinds of grain are relished best. Different kinds of ground feed are readily eaten but particularly are those relished where corn and oats form a considerable portion of the mixture. Whole wheat and whole oats are readily eaten.

Tables I and II, give in detail the growth of thoroughbred Shropshire and Dorset lambs in the experiment of 1891–2. The weights are given in pounds.

TABLE NO. I.—RECORD OF GROWTH.

Thoroughbred Shropshires, 1892.

NUMBER OF LAMB.	Weight at birth. lbs. oz.	Weight 2d week.	Weight 3d week.	Weight 4th week	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.
2	10 1	16.75	22.5	30.00	33.5	39.5	44.5	45.5	51.00
5	8 5	11.75	14.75	19.00	22.00	23.5	27.5	31.5	34.5
17	10 13	13.5	15.5	......	......	......	......	......	....
18	9 8	11.5	14.00	......	......	......	......	......	....
Average weight	9 11	13.37	16.68	24.5	27.75	31.5	36.00	39.00	42.75
Average gain	......	......	3.31	5.88	3.20	3.75	4.50	3.00	3.75

Average gain for whole time.. 3.91

TABLE NO. II.— RECORD OF GROWTH.

Thoroughbred Dorsets, 1892.

NUMBER OF LAMB.	Weight at birth.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.
	lbs. oz.								
3....................	11 8	17.25	23.5	30.5	36.5	42.00	47.00	49.5	56.00
4....................	8 14	13.50	18.25	24.00	30.5	36.5	42.5	45.5	51.00
7....................	11 6	13.00	17.5	23.00	......	......	......	.....	....
Average weight	10 9	14.58	19.75	25.8	33.5	39.25	44.7	47.5	53.5
Average gain	......	......	5.17	6.05	6.3	5.75	5.45	2.80	6.0

Average gain for whole time.. 5.36

While the number of lambs of each breed was small the difference in gain was so great that it is worthy of notice. The Dorset lambs were the largest at birth and gained more each week throughout the whole period of feeding than did the Shropshires, although the greatest gain was made after the fourth week. The Dorset ewes had the appearance of being heavier milkers than the Shropshires, and the lambs consequently were stronger and made more growth.

Tables III and IV show the weekly gain of thoroughbred Shropshire and Dorset lambs for 1892–93. From these tables it will be seen that as in the former year the Dorsets made the greater gain. While the number of Shropshire lambs in this test were larger than the Dorsets it must not be inferred that the Shropshires could have made as good a record as the Dorsets had the best been selected, for the very best did not equal the average of the Dorsets.

In all the tests both the ewes and the lambs were given all the food they would consume ; the food given the two breeds was the same in quality but oftentimes differed considerably in quantity. The Dorset ewes consumed more food than the Shropshires and their appetite seemed less affected by changes in the weather than was the case with the Shropshires. From experiments in feeding these two breeds for three years it was noticed that the Dorsets were the best feeders ; not only did they stand forced feeding better, but were less affected by unfavorable atmospheric changes.

TABLE NO. III.—RECORD OF GROWTH.

Thoroughbred Shropshires, 1893.

NUMBER OF LAMB.	Weight at birth.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.	Weight 11th week.
12	8.00	12.34	15.20	18.12	23.80	27.84	30.20	32.56	36.62	38.60	41.74	45.79
20	4.75	7.34	10.66	14.20	16.76	20.24	23.54	27.56	32.60	34.23	38.81	41.82
21	5.70	7.70	10.82	13.56	14.90	15.90	17.62	19.96	20.90	24.00	27.75	31.19
23	5.40	5.52	7.34	9.84	12.30	14.90	18.24	19.94	19.10	20.88	23.09	23.60
24	7.46	8.94	13.26	16.98	19.74	22.60	26.14	28.10	31.70	35.08	41.20	43.67
30	8.40	9.80	13.58	17.36	20.40	24.60	28.42	33.18	33.92	38.18	40.70	.....
32	5.93	9.30	12.60	19.08	18.80	21.30	21.62	24.62	28.40	....	....	.....
Average	6.51	8.70	11.92	15.16	18.70	21.05	23.68	26.56	29.03	31.82	35.54	37 21
Average gain	....	2.19	3.22	3.24	3.54	2.35	2.63	2.88	2.49	2.68	3.72	2.70

Average for whole time.. 2.87

TABLE NO. IV.—RECORD OF GROWTH.

Thoroughbred Dorsets, 1893.

NUMBER OF LAMB.	Weight at birth.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.	Weight 11th week.	Weight 12th week.
1	9.46	15.22	18.85	24.55	28.96	33.30	38.85	42.84	47.76	....	....	....	.....
2	11.54	17.80	23.32	28.34	32.70	36.75	41.76	46.26	50.40	54.90	59.94	60.22	64.46
3	10.55	15.00	19.44	23.00	27.88	31.90	37.00	41.90	47.74	52.52	56.64	60.64	64.84
Average	10.51	16.00	20.53	25.29	29.84	33.98	39.20	43.66	48.63	53.71	58.29	60.43	64.65
Average gain	....	5.49	4.53	4.76	4.55	4.14	5.22	4.46	4.94	4.64	4.58	2.14	4.22

Average for whole time.. 4.47

Tables V and VI give the growth of lambs from thoroughbred males and grade merino ewes.

It will be noticed that the grade Dorsets made a much better growth than the Shropshires.

In selecting ewes for these two flocks care was taken to have the flocks as near alike as to age, breeding and general appearance as it was possible to make them. Whenever the ewes selected for these two flocks were those that were retained from the previous years' purchase, their previous record was taken into account.

TABLE NO. V. — RECORD OF GROWTH.

Grade Shropshires, 1893.

NUMBER OF LAMB.	Weight at birth.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.	Weight 11th week.	Weight 12th week.
9	7.90	9.78	11.94	15.40	18 94	21.16	24.56	26.66	29.60	33.10	37.00	39.20	41.66
10	9.10	8.20	9.94	13.50	15.30	17.86	20.22	22.70	25.90	28.74	30 10	31.40	35.93
11	8.80	10.66	14.12	18.66	23.00	25.94	29.16	32.90	36.80	41.46	45.54	47.94	.....
13	8.36	10.96	13.50	15.12	18.46	21.66	23.44	27.16	27.14	29.68	32.50	35 96	.....
14	8.90	11.68	14.54	17.94	20.20	22.38	25.34	28 54	30.26	30.36	32.74	35.25	38.00
15	10.00	13.60	18.00	21.30	23.36	26.78	29.56	33.72	35.20	37.50	39.90	45.30	49.10
16	8.20	8.60	12.52	16.42	19.12	22.70	26.66	28.20	31.23	31.00	34.30	34.52	39.82
17	10.36	12.16	15.82	19.58	23.84	26.86	29.94	32.10	35.40	37.70	40.65	42.77	.....
19	10.16	15.34	20.42	25.18	29.30	32.94	36.70	42.80	44.46	....	....	....	.....
25	7.00	10.60	15.18	18.26	21.64	26.16	28.80	33.10	35.10	38.88	38.79	....	.....
26	7.52	10.92	14.82	17.56	20.05	22.70	24.00	28.60	30.60	33.30	35.94	....	.....
Average	8.75	11.13	15.52	18.08	21.20	24.28	27.12	30.58	32.82	33.94	36.74	39.04	40.90
Average gain	....	2.38	4.39	2.56	3.12	3.08	2.84	3.46	2 30	2.22	2.80	2.30	2.83

Average for the whole time 2.66

TABLE NO. VI. — RECORD OF GROWTH.

Grade Dorsets, 1893.

NUMBER OF LAMB.	Weight at birth.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.	Weight 11th week.
4	9.92	14.60	18.34	21.20	24.65	28.54	33.06	37.20	42.14	45.30	.....	.....
5	9.62	11.50	15.26	18.84	23.00	27.80	32.76	37.74	40.44	44.62	49.30	53.12
6	12.48	16.38	20.30	29.14	26.64	31.10	36.52	41.80	.....	.....	.....	.....
7	11.54	13.80	17.20	19.76	24.14	28.88	31.20	33.84	34.22	34.66	37.60	40.74
8	11.40	16.00	21.30	26.34	31.96	36.52	41.70	46.36	49.72	.....	.....	.....
18	5.40	9.24	12.72	15.96	19.06	23.10	26.80	31.00	34.68	37.43	40.58	.....
31	12.38	16.40	20.64	24.18	27.70	30.74	33.80	36.90	41.10	.....	.....	.....
Average	10.39	13.99	17.96	21.20	25.30	29.52	33.69	37.83	40.39	40.51	42.49	46.93
Average gain	....	3.60	3.97	3.24	4.10	4.20	4.17	4.14	3.24	2.63	3.59	3.18

Average for the whole time 3.64

Tables VII and VIII give the date of birth, weight at birth and record of growth of Grade Shropshire and Grade Dorset lambs of 1893–4. A considerable larger number of ewes were used in this experiment than in the experiment of the previous year. It will be noticed here also, that so far as the growth of the lambs are concerned, the grade Dorsets show a considerable gain over that of the Shropshires. The weight of the lambs at birth of the two lots do not differ materially, yet the average gain per week for the whole time of the Dorsets over that of the Shropshires is considerable, and of great importance, if the highest market prices are to be secured. The ewes of these two lots were of equal age, size and general appearance, also in breeding so far as their appearance would indicate. Nearly all of these ewes were purchased of a large breeder of merino sheep who disposed of them on account of their advanced age.

These ewes were of good size, many of them weighing from 90 to 110 pounds when in good condition. They were hearty and, as a rule, were able to consume a fairly liberal grain ration. It must be remembered, however, that these sheep had never before been subjected to a forced feeding for large milk production, and consequently gave a smaller quantity of milk than they would have given had their capacity been developed by liberal feeding calculated to produce this effect for several years previous.

The question has been asked if corn silage can be substituted for roots in the ration for ewes when winter lambs are the chief object. This question is of considerable importance to every early lamb raiser who practices ensilaging corn for his dairy. If corn silage will take the place of beets or turnips as a food for this class of sheep, considerable expense can be saved where silos are in use, by feeding the silage as a succulent food instead of roots, since a little extra corn can be grown and put in the silo under these conditions, and at a less expense, than the same feeding value of roots can be grown and harvested.

TABLE No. VII.— RECORD OF GROWTH — *Grade Shropshires*, 1894.

NUMBER OF LAMB.	Date of birth.	Weight at birth.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.
7	Dec. 28	9.80	11.94	15.68	19.80	23.13	27.10	30.50	35.22	40.00	47.50	48.90
8	Dec. 31	8.00	7.78	10.94	11.20	13.60	15.90	19.60	22.82	27.18	31.16	36.70
9	Dec. 31	8.40	8.20	10.70	12.30	14.56	17.00	20.80	22.66	26.52	31.90	37.20
10	Jan. 7	10.03	10.94	13.24	15.80	17.24	21.14	24.46	29.32	34.36	40.10	41.50
13	Jan. 9	11.40	14.88	18.90	22.44	26.50	31.10	35.24	37.30	40.10	45.10	.....
17	Jan. 11	9.10	10.40	13.80	16.44	19.00	21.18	24.86	28.50	32.60	34.50	37.60
18	Jan. 12	11.20	13.84	18.90	24.44	28.30	33.40	39.12	43.72	.....	.....	.....
21	Jan. 27	9.62	10.84	13.90	17.64	21.62	25.00	29.60	39.50	44.00	.....	.....
22	Jan. 30	12.10	15.90	19.22	24.48	27.58	30.60	34.40	38.30	44.10	.....	.....
23	Jan. 30	8.10	11.30	14.40	17.84	21.83	25.30	28.40	31.70	33.59	38.50	43.88
24	Jan. 31	9.10	13.50	17.46	21.14	25.14	28.80	31.40	35.50	39.40	41.90	45.60
33	Feb. 11	9.74	9.74	14.56	18.46	22.70	25.80	30.30	34.39	37.00	.....	43.52
35	Feb. 13	10.60	14.82	17.00	20.00	23.20	26.70	29.40	31.41	37.82	42.42	.....
37	Feb. 14	10.20	12.36	15.50	19.00	22.50	26.70	30.19	33.47	34.46	26.68	.....
44	Feb. 18	9.10	10.64	13.13	17.00	19.60	22.20	24.70	27.20	31.16	33.46	.....
46	Feb. 18	8.70	9.48	12.00	16.14	19.40	21.75	24.80	26.91	30.48	33.14	.....
47	Feb. 19	9.20	9.20	13.30	17.00	21.80	26.00	28.40	36.40	37.32	.....	.....
52	Mar. 9	8.80	10.30	13.90	15.24	18.00	20.14	22.04	.....	.....	.....	.....
59	Mar. 16	9.30	9.20	12.98	16.35	19.86	23.30	.....	.....	.....	.....	.....
Average	....	9.60	11.33	14.71	18.08	21.34	24.69	28.22	32.60	35.63	38.03	41.86
Average gain per week	....	....	....	3.38	3.37	3.26	3.35	3.53	4.38	3.03	2.40	3.83

Average for whole time.......................................3.20.

TABLE NO. VIII.—RECORD OF GROWTH OF GRADE DORSET LAMBS.

NUMBER OF LAMB.	Date of birth.	Weight at birth.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.
6	Dec. 27	10.00	13.40	18.10	24.30	28.90	33.10	38.04	42.26	48.26	52.16	55.50
16	Jan. 10	11.00	14.60	17.88	20.60	25.00	28.82	34.22	37.40	42.80	45.20	.....
19	Jan. 20	11.60	12.60	16.90	21.40	26.16	30.78	35.20	40.10	42.70	.....	.....
20	Jan. 21	10.30	10.96	15.30	19.78	24.12	28.26	31.80	32.90	35.50	40.10	42.40
25	Feb. 2	6.80	7.80	12.36	16.60	20,20	24.90	27.10	30.80	34.20	38.21	42.08
29	Feb. 7	9.80	11.16	14.18	16.80	20.00	22.00	22.20	22.60	28.60	.....	.....
31	Feb. 10	10.30	12.16	17.42	21.70	26.76	29.90	32.00	33.80	37.10	41.06	.....
32	Feb. 10	11.10	12.02	16.62	21.40	26.00	29,74	34.70	39.29	43.00	50.18	.....
36	Feb. 13	8.90	11.64	14.50	17.80	20.10	23.30	26.10	29.03	32.04	36.54	.....
40	Feb. 15	10.40	10.70	15.32	18.40	24.30	25.80	29.40	35.39	40.24	44.18	.....
43	Feb. 17	9.40	10.98	13.66	16.90	19.20	22.30	24.50	27.90	30.46	34.58	.....
45	Feb. 18	9.60	10.00	13.40	17.50	20.00	23.20	26.17	28.81	32.50	34.26	.....
48	Feb. 21	11.60	13.96	18.00	21.60	25.10	28.19	31.90	35.46	38.04	.....	.....
49	Feb. 22	8.70	10.20	13.74	17.40	20.24	22.70	26.20	29.46	33.08	.....	.....
57	Mar. 16	7.90	9.94	12.19	14.60	17.12	18.32	.....	.....	.....	.....	.....
58	Mar. 16	6.90	8.00	9.54	10.50	12.00	13.10	.....	.....	.....	.....	.....
60	Mar. 16	7.10	9.10	11.00	13.81	16.62	18.54	.....	.....	.....	.....	.....
Average	......	9.49	11.13	14.71	18.30	21.87	24.88	29.96	33.23	37.03	41.65	46.66
Average gain per week	... ..	.....	1.64	3.58	3.59	3.57	3.01	5.08	3.27	3.80	4.62	5.01

Average gain for whole time..3.95.

The number of letters of inquiry received at this Station seem to demand a better knowledge than we possessed of the feeding value of ensilage in a ration for ewes giving milk. Consequently, two small flocks, consisting of eight grade Merino ewes each were selected with a view to compare the value of corn silage with that of mangel-wurzel. The ewes selected were good sized mature sheep, quite uniform in appearance. From each pen, seven lambs were raised. The following tables (IX and X) give the weights each week of each lamb and also their averages and gain. It will be observed that very little difference is shown by these records between the feeding values of these two foods.

TABLE NO. IX. — RECORD OF GROWTH.

Ewes Fed Roots, 1893.

NUMBER OF LAMB.	Weight at birth.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.	Weight 11th week.
7	11.54	13.80	17.20	19.76	24.14	28.84	31.20	33 84	34.22	34.66	37.60	40.74
8	11.40	16.00	21.30	26.34	31.96	36.52	41.70	46.36	49.72	....	....	.....
13	8.36	10.96	13.50	15.12	18.46	21.66	23.44	27.16	27.14	29.68	32.50	35.96
15	10.00	13.60	18.00	21.30	23.36	26.78	29.56	33.72	35.20	37.50	39.90	45.30
17	10.36	12.16	15.82	17.58	23.84	26.86	29.94	32.10	35.40	37.70	40.65	42.77
19	10 16	15.34	20.42	25.18	29.30	32.94	36.70	42.80	44.46	....	....	.....
31	12.38	16.40	20.64	24.18	27.70	30.74	33.80	36.90	41.90	....	....	.....
Average	10.59	14.03	18.12	21.63	25.53	29.19	32.33	36.12	38.29	34.88	37.66	41.19
Average gain	....	3.44	4.09	3.51	3.90	3.66	3.14	3.79	2.17	1.89	3.55	3.53

Average for the whole time 3.22

TABLE NO. X.—RECORD OF GROWTH.

Ewes Fed Ensilage, 1893.

NUMBER OF LAMB.	Weight at birth.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.	Weight 11th week.
4	9.92	14.60	18.34	21.20	24.64	28.54	33.06	37.20	42.14	45.30	....	.....
5	9.62	11.50	15.26	18.84	23.00	27.80	32.76	37.74	40.44	44.62	49.30	53.12
9	7.90	9.78	11.94	15.40	18.94	21.16	24.56	26.66	29.60	33.10	37.00	39.20
11	8.80	10.66	14.12	18.66	23 00	25.94	29.16	32.90	36.80	41.46	45 54	47.94
14	8.90	11.68	14.54	17.94	20.20	22.38	25.34	28.54	30.26	30.36	32.74	35.25
16	8.20	8.60	12.52	16.42	19.12	22.70	26.66	28.20	31.23	31.00	34.30	34.52
35	6.28	5 90	7.02	9.00	10.74	12.82	15.78	....	....	....	....	.....
Average	8.51	10.38	13.39	16.78	19.94	23.05	26.76	31.87	35.08	37.64	39.77	42.01
Average gain	....	1.87	3.01	3.39	3.16	3.11	3 71	3.28	3.21	2.56	3.66	2.23

Average for the whole time 3.13

Tables XI and XII give the amount of food consumed from January 17th to April 15th by the two lots. The roots were the long red mangel-wurzel, good size, well matured. The ensilage corn was Sibley's Pride of the North, planted in hills three feet apart each way, and cut and put in the silo when an average ear was just beginning to glaze. The corn was a heavy crop, well eared and nearly all of the ears were put in the silo with the stalks.

TABLE XI.—LOT I.

	Hay.	Water.	Roots.	Total grain.
January	326.50	760.5	31.5	....
February	474.5	1391.5	714.	....
March	308.	1358.	744.	....
April	138.5	572.	436.	....
Total	1247	4082.	1926.	714.

TABLE XII.—LOT II.

	Hay.	Water.	Ensilage.	Total grain.
January	304.	770.	131.5	....
February	447.	1655.	687.	....
March	288.5	1411.	653.	....
April	97.	685.	285.	....
Total	1137.	4522.	1757.	762.

The grain fed these two lots consisted of two parts bran, one part corn meal and one part cotton seed meal.

During the time this grain was fed, the sheep had all they would readily consume twice a day. The roots and ensilage were fed but once a day in as large quantities as would be readily eaten. The coarser part of the corn stalks in the ensilage was not consumed, and was weighed back and deducted from the amount of ensilage weighed out. The hay was a good quality of mixed hay, largely clover, fed twice a day in such quantities as were readily consumed.

In this connection it may be said that good clover hay is one of the requisites to success in raising early lambs. While bean straw or other coarse fodder, rich in nitrogen, may be substituted in part, yet there is no coarse fodder so good as first quality clover hay.

In order to make a more thorough trial of the comparative feeding value of ensilage and roots, the succulent food for ewes rearing early lambs, the experiment of 1893 was repeated. In this trial somewhat larger flocks were taken, otherwise the experiment was carried out in all details the same as the one of the previous year.

Each lot consisted of 16 ewes, and from each pen 15 lambs were raised, one ewe in each lot failed to breed.

Tables XIII and XIV give the record of the growth of the lambs of each lot.

It will be observed that the lambs of each lot were grade Shropshires and grade Dorsets, and that these were nearly as equally divided as possible, so that whatever gain one lot may have made over the other was due to the difference of the food consumed and not to any difference to breeding. These sheep were fed ensilage once a day in as large quantities as would be readily consumed. They learned to like the ensilage almost as readily as they did the beets, and it seemed evident that neither ensilage nor beets had been given these sheep before this experiment was commenced.

TABLE XIII.—RECORD OF GROWTH.

Ewes Fed Roots, 1894.

NUMBER OF LAMB.	Date of birth.	Breed.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week.	Weight 10th week.	Weight 11th week.
6................	Dec. 27	G. D.	13.40	18.10	24.30	28.90	33.10	38.04	42.26	48.26	52.16	55.50	60.90
8................	Dec. 31	G. S.	7.78	10.94	11.20	13.60	15.90	19.60	22.82	27.18	31.16	36.70	40.30
9................	Dec. 31	G. S.	8.20	10.70	12.30	14.56	17.00	20.80	22.66	26.52	31.90	37.20	38.90
10................	Jan. 7	G. S.	10.94	13.24	15.80	17.24	21.14	24.46	39.32	34.36	40.10	41.50	.....
16................	Jan. 10	G. D.	14.60	17.88	20.60	25.00	28.82	34.22	37.40	42.80	45.20	....	.....
17................	Jan. 11	G. S.	10.40	13.80	16.44	19.00	21.18	24.86	28.50	32.60	34.50	37.60	43.50
18................	Jan. 12	G. S.	13.84	18.90	24.44	28.30	33.40	39.12	43.72	....	....	....	.....
19................	Jan. 20	G. D.	12.60	16.90	21.40	26.16	30.78	35.20	40.10	42.70	....	....	.....
20................	Jan. 21	G. D.	10.96	15.30	19.78	24.12	28.26	31.80	32.96	35.50	40.10	42.40	.....
22................	Jan. 30	G. S.	15.90	19.22	24.48	27.58	30.60	34.40	38.30	44.10	....	....	.....
25................	Feb. 2	G. D.	7.80	12.36	16.60	20.20	24.90	27.10	30.80	34.20	38.31	42.08	.....
30................	Feb. 9	G. S.	10.78	15.12	18.18	23.40	26.24	30.50	32.70	36.50	42.70	....	.....
31................	Feb. 10	G. D.	12.16	17.42	21.70	26.76	29.90	32 00	33.80	37.10	41.06	....	.....
36................	Feb. 13	G. D.	11.64	14.50	17.80	20.10	23.30	26.10	29.03	32.04	36.54	....	.....
40.............. ..	Feb. 15	G. D.	10.70	15.32	18.40	24.30	25.80	29.40	35.39	40.24	44.18	....	.....
Average..........	....	....	11.45	15.31	18.89	22.61	26.02	29.84	33.98	36.72	39.82	41.85	45.90
Average gain per week..........	....	....	....	3.86	3.58	3.72	3.41	3.84	4.14	2.74	3.10	2.03	4.05

Average gain for whole time ....3.44.

TABLE XIV.— RECORD OF GROWTH.

Ewes Fed Ensilage, 1894.

NUMBER OF LAMB.	Date of birth.	Breed.	Weight 1st week.	Weight 2d week.	Weight 3d week.	Weight 4th week.	Weight 5th week.	Weight 6th week.	Weight 7th week.	Weight 8th week.	Weight 9th week	Weight 10th week.
7	Dec. 28	G. S.	11.94	15.68	19.80	23.13	27.10	30.50	35.22	40.00	47.50	48.90
13	Jan. 9	G. S.	14.88	18.90	22.44	26.50	31.10	35.24	37.30	40.10	45.10	.....
21	Jan. 27	G. S.	10.84	13.90	17.64	21.62	25.00	29.60	39.50	44.00	....	.....
23	Jan. 30	G. S.	11.30	14.40	17.84	21.83	25.30	28.40	31.70	33.59	38.50	43.88
24	Jan. 31	G. S.	13.50	17.46	21.14	25.14	28.80	31.40	35.50	39.40	41.90	45.60
29	Feb. 7	G. D.	11.16	14.18	16.80	20.00	22.00	22.20	22.60	28.60	....	.....
32	Feb. 10	G. D.	12.02	16.62	21.40	26.00	29.74	34.70	39.29	43.00	50.18	.....
33	Feb. 11	G. S.	9.74	14.56	18.46	22.70	25.80	30.30	34.39	37.00	43.52	.....
37	Feb. 14	G. S.	12.36	15.50	19.00	22.50	26.70	30.19	33.47	34.46	36.68	.....
43	Feb. 17	G. D.	10.98	13.66	16.90	19.20	22.30	24.50	27.90	30.46	34.58	.....
45	Feb. 18	G. D.	10.00	13.40	17.50	20.00	23.20	26.17	28.81	32.50	34.26	.....
48	Feb. 21	G. D.	13.96	18.00	21.60	25.10	28.19	31.90	35.46	38.04	....	.....
49	Feb. 22	G. D.	10.20	13.74	17.40	20.24	22.70	26.20	29.46	33.08	....	.....
52	Mar. 9	G. S.	10.30	13.90	15.24	18.00	20.14	22.04	....	....	....	.....
60	Mar. 16	G. D.	9.10	11.00	13.81	16.62	18.54	....	....	....	....	.....
Average weight	....	......	11.48	15.03	18.46	31.90	25.10	28.81	33.12	36.48	41.35	46.12
Average gain per week	....	......	......	3.55	3.43	3.44	3.20	3.71	4.31	3.36	4.87	4.77

Average gain for whole time..........3.85

Table XV gives the amount of hay, water, roots and grain consumed by the flock fed roots, and table XVI gives the amount of water and food consumed by the flock fed ensilage.

Table XV.

	Hay.	Water.	Roots.	Corn and oats.	Meal.*
January	1368	3248	467	156.5	33
February	1549	4307	664	191.	224
March	1350	3767.5	661	239.	239
April	350	862	240	82.	86
Total	4617	12184	2032	688	622

Table XVI.

	Hay.	Water.	Ensilage.	Corn and oats.	Meal.*
January	1040	2480	433	156	73
February	1036	3115	705	188	224
March	1130	3595	729	248	248
April	460	1179	335	117	125
Total	3666	10369	2202	709	670

The record of the food consumed extends from January 2d to April 19th. It will be noted that the flock given the ensilage consumed somewhat more of this food than was consumed of beets by the beet-fed flock. A little more grain was consumed by the sheep fed ensilage than by those fed beets. This difference, however, was hardly great enough to denote a greater appetite caused by the ensilage.

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* Two parts bran, one part corn meal, and one part cotton seed meal.

Tables XVII, XVIII, XIX and XX give the records of weights, dressed weight, loss in dressing, age in days of the Grade Shropshires and Dorset lambs, slaughtered in 1893 and 1894. It will be noticed that the Dorset lambs were slaughtered at a somewhat younger age than were the Shropshires and that their weight dressed was also a little greater than that of the Shropshires. Practically there was no difference in the amount which these two breeds lost in weight by dressing.

TABLE XVII — RECORD OF SLAUGHTERING GRADE — SHROPSHIRE LAMBS, AND THE PRICES FOR WHICH THEY WERE SOLD, 1893.

DATE.	No. of lamb.	Live weight.	Dressed weight.	Loss in dressing.	Age in days.	Amount of sale.
Apr. 18..	11	50.24	34.44	15.80	74	$6 00
Apr. 18..	19	45.74	33.70	12.04	57	6 00
May 1..	9	46.30	34.76	11.54	88	6 00
May 1..	15	49.00	32.50	16.50	82	6 00
May 1..	17	40.30	31.00	9.30	73	6 00
Average..	......	46.31	33.28	13.03	74.8	$6 00

TABLE XVIII — RECORD OF SLAUGHTERING GRADE DORSET LAMBS AND THE PRICES FOR WHICH THEY WERE SOLD, 1893.

DATE.	No. of lamb.	Live weight.	Dressed weight.	Loss in dressing.	Age in days.	Amount of sale.
Feb. 15..	1	48.62	37.16	11.46	58	$10 00
Mar. 7..	4	45.58	33.82	11.76	65	7 00
Mar. 7..	6	42.80	31.36	11.44	51	8 50
Mar. 27..	5	53.12	38.46	14.69	74	8 00
Mar. 27..	8	49.72	35.81	14.91	55	8 00
Apr. 18..	7	41.54	25.44	16.10	79	3 00
May 1..	31	40.70	31.60	9.10	55	6 00
Average..	......	46.01	33.37	12.77	62.42	$7 14

TABLE XIX — RECORD OF SLAUGHTERING GRADE SHROPSHIRE LAMBS, 1894.

DATE.	Number of lamb.	Live weight.	Dressed weight.	Loss in dressing.	Age in days.
February 28	7	48.90	35.50	13.40	62
March 12	8	40.30	28.50	11.80	71
March 27	9	43.10	30.04	13.06	86
March 12	10	45.10	33.90	11.20	64
March 12	13	41.50	28.60	12.90	62
March 27	17	45.00	32.20	12.80	75
February 28	18	45.00	34.00	11.00	47
March 27	21	44.00	30.82	13.18	59
April 10	22	45.80	33.10	12.70	70
March 27	23	44.10	31.80	12.30	56
April 10	24	45.60	35.00	10.48	69
April 10	30	42.70	30.80	11.90	60
April 10	33	43.52	32.08	11.44	58
April 16	35	42.42	29.50	12.92	62
April 30	37	47.64	32.34	14.30	75
April 30	47	43.64	32.27	11.37	70
Average	....	44.27	31.90	12.29	65

TABLE XX — RECORD OF SLAUGHTERING GRADE DORSET LAMBS, 1894.

DATE.	Number of lamb.	Live weight.	Dressed weight.	Loss in dressing.	Age in days.
March 12	6	60.90	44.40	16.50	75
March 12	16	45.20	31.90	13.30	61
March 12	19	42.70	32.80	9.90	51
March 27	20	42.40	30.50	12.10	65
April 10	26	42.08	30.28	11.80	66
April 16	31	40.50	31.80	8.70	65
April 10	32	50.18	34.41	15.77	59
April 16	40	44.18	30.75	13.43	60
Average	....	46.02	33.35	12.68	63

Table XXI gives the number of lambs, date of killing, date of sale and price per head. In marketing these lambs, it was found necessary to have them present a neat and inviting appearance when exposed for sale if best prices were to be obtained. Of course size and fatness are of prime importance and it is also equally important that these conditions be obtained early in the life of the lamb before it presents what is known as a "staggy" appearance. As the season advances, it will be found necessary to have the lambs larger than during the first of the early lamb market. The late market seems to demand greater weight than the early market. From several visits at various commission houses in New York it has been learned that care and skill in dressing the lambs and preparing them for market is almost of as much importance as the care and skill in fattening the lamb. Particularly is this true of lambs of ordinary condition. On one visit to a commission house a lot of lambs was noticed for which the commission merchant asked $3.00 per head and had remained unsold for several days. Assurance was given that this same lot would have met with ready sale at $6.00 per head had they been properly prepared for the market. In preparing lambs for shipments, certain precautions should be observed.

The following table gives the date of killing, the date of sale and the prices for which the lambs were sold in New York in 1894:

TABLE XXI.

DATE OF KILLING.	No. of lamb.	Date of sale.	Price per head.	Total.
February 28........	7	March 1	1 at $7.00	
February 28........	18	March 1	1 at 6.50	$13 50
March 12..........	6	March 14	2 at 6.00	
March 12..........	8	March 14		
March 12..........	10	March 14	2 at 5.00	
March 12..........	13	March 14		
March 12..........	16	March 14	2 at 4.00	30.00
March 12..........	19	March 14		
March 27..........	21	March 28		
March 27..........	23	March 28	2 at 6.00	
March 27..........	20	March 28		
March 27..........	9	March 28	3 at 5.00	27.00
March 27..........	17	March 28		
April 10...........	26	April 11		
April 10...........	30	April 11		
April 10...........	24	April 11	4 at 5.50	
April 10...........	33	April 11		
April 10...........	32	April 11	2 at 5.00	32.00
April 10...........	22	April 11		
April 16...........	31	April 18		
April 16...........	35	April 18	3 at 4.00	12.00
April 16...........	40	April 18		
April 30...........	37	May 2		
April 30...........	47	May 2	2 at 3.00	6.00

It will be seen that the lambs sent early in the market sold for the highest price, and in this respect the market for early lambs in 1894 did not materially differ from the markets of other years. As a rule, the early market is the best. It is true that the lambs sent at this time are likely to be a little better in quality, as those which fatten best are sent first to the market, so naturally the best lambs will be sent to the market a little earlier than the poorer lambs; and when we consider the prices at which earlier lambs are sold in the New York market during the winter and spring months, this point should be borne in mind. Early lambs are usually sold by the head until Tennessee lambs come to market, then all lambs are sold by the pound. The exact time at which this occurs will vary from year to year.

Sometimes the early lamb market keeps up well until the last of April or even the fore part of May.

The expense of sending lambs to New York will vary greatly throughout the different parts of the State. From points where competing express companies run to New York reasonable express rates may be obtained. From Ithaca to New York the rate is 80 cents per hundred weight.

32.—Nicely dressed.

33.—Ready for shipment.

Sometimes it is of considerable importance that the lambs arrive in New York early in the week. As a rule the Tuesday or Wednesday market is the best. The wholesale market practically closes Friday noon, so lambs ought to reach New York in ample time to be sold before the wholesale market closes.

Some precautions to be taken in dressing lambs.—In order to secure the most perfect bleeding and at the same time to prevent the wool about the head and neck from being soiled it is best to suspend the lamb by the hind feet so that its head will clear the floor by a foot or more.

In bleeding the lamb an opening should be made only on one side of the neck, preferably the left side, immediately back of the head and in front of the cervical vertebra (neck bones). The opening need not be large, but it will be necessary to give the knife blade a considerable sweep in order to be sure that the large artery is severed. The stomach and intestines should be removed without disturbing the heart, lungs or liver. As soon as the intestines are removed spreaders should be inserted to give the lamb the best appearance when offered for sale. For lambs weighing from thirty to forty pounds dressed weight, spreaders about 14 inches long will be about the right length. If too long spreaders are used there is danger of breaking the ribs and thereby injuring the appearance. At each end of the spreader should be made a shoulder and a projecting point; one of these points should be inserted from the outside at the flank near the opening made for the removal of the intestines, the spreader crossing the back diagonally and the point at the other end inserted in a similar manner in the opposite side of the lamb near the chest. In like manner a second spreader is inserted so that the two cross each other forming an X at the back of the lamb. The caul fat should then be fastened by means of two skewers at the thighs and the points of the spreaders, in such a manner that the whole of the meat, not covered with the skin is covered with the caul fat and in this condition the lamb should be allowed to cool. It is of the utmost importance that all of the animal heat be given off before the carcass is wrapped for shipment. Many lambs have reached the market in a bad condition from lack of proper cooling immediately after slaughtering. This is more frequently observed in the spring months during warm weather.

Before shipment each lamb should be wrapped with two separate wrappings, the inner wrapping to be of plain tough paper or muslin (if muslin is used one yard for each lamb is sufficient.) This should be so put on that it will draw tightly over the front of the lamb to prevent breaking and soiling by handling. An outer covering of burlap or sacking should be added before shipment.

From the inspection given a large number of lambs in the New York markets, it was evident that often insufficient provision is made for removing all of the bloody liquid from the chest. In the ordinary way of slaughtering lambs, more or less liquid will accumulate at this point and unless it is removed serious injury to the appearance of the lamb, when shown for sale, is likely to occur. To effectually remove this, an opening should be made with a large knife at the lower part of the chest and kept free until the chest is completely drained. This should always be done while the carcass is yet hanging up.

SUMMARY.

It is of the utmost importance that the lambs be fat.

The market early in the season does not require so large lambs as the late market. The best early market commences as soon as the holiday poultry is out of the way, usually about the middle of January.

Other things being equal, ewes that give the most milk, breed earliest in the season.

The Dorset Horn sheep have bred earlier and fatted better lambs than the Shropshires.

There is practically no difference between beets and ensilage as a succulent food for ewes rearing early lambs.

Dressed lambs should reach the New York market as early in the week as possible; as Saturday is retailers' day, the lambs ought to be sold before Friday noon.

As a coarse fodder for the ewes and also for the lambs there is nothing better than good clover hay. In fact this is one of the essentials to success in early lamb raising.

As a rule ewes respond more liberally to forced feed for milk production the second year than they do the first.

The manner in which the lambs are dressed determines to quite an extent their selling price. Neatly dressed lambs are always preferred to those of like quality poorly dressed.

Ewes should not be forced for milk production until the lambs are a few days old.

Be sure that the animal heat is all out of the carcass before wrapping up for shipment; particularly is this of the utmost importance in warm weather.

An opening should be made to remove the blood from the chest before shipment.

GEORGE C. WATSON.

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84. The Recent Apple Failures in Western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.

Feeding Pigs.

On account of the extremely low price of wheat fort he past year a great deal more has been fed to stock than usual, and by men who have had little or no experience in feeding it. In the feeding of wheat as in every other new departure, the lack of facts and reliable data concerning the results of previous work in this line frequently hindered those who had wheat to feed, from obtaining the best results under the circumstances. Particularly was a comparison of the feeding value of wheat with one or more of the most common foods needed to help those to compound a ration who have little knowledge of the chemical composition of feeding stuffs. Until quite recently, comparatively few experiments have been made to determine the feeding value of wheat because the price for flouring purposes prevented its use as a food for animals in a practical way. Now, however, many farmers who raise wheat are confronted with the problem, "can I afford to sell wheat at the market price and buy food for stock?" Of course the character and quantity of the coarse fodder to be fed in connection with the grain, should determine largely whether wheat is the most economical of the concentrated foods to feed with it, but aside from this the question of selling wheat and buying corn meal, oats and bran has been one not easy to solve by those confronted with it. It has been said that farmers in this State should not raise wheat; that at the present prices it can be purchased in the market cheaper than it can be grown on the improved land with high priced labor. While this may be true to a great extent, the fact still remains that this crop has taken its turn in the regular four or five years' rotation and can not be left out without changing the whole system of farming. In many instances no doubt, the system will eventually be changed, but it will take several years to bring it about. Farmers as a rule are conservative and hesitate to try new departures except in a small way at first. This will be a great influence in continuing the cultivation of wheat in New York State for several years to come, although the money received for the grain may be insufficient to meet the expenses of raising and marketing the crop. Then, too, the wheat straw is often the chief stable absorbent in the grain districts and is of great value for this purpose. As the number of animals on the farms is increasing, particularly in the dairy districts, the question of providing absorbents for the preservation of manure is not always easily solved. In view of all these facts it is safe to assume that wheat will be raised for many years in this State and that a larger portion than formerly will be fed on the farms.

In order to make a comparative test of the value of the wheat product with that of corn as a food for pigs, the food was so mixed that the grain fed of each kind had the same chemical composition, so far as the nutritive ratio was concerned. It was found by mixing twenty-six pounds of gluten feed with one hundred pounds of corn meal that the nutritive ratio of the mixture was practically the same as that of wheat. This mixture was fed to one lot of pigs and ground wheat to another. Each lot received equal amounts of skim milk.

September 25, 1894, twelve barrows were selected from a uniform lot of thirty pigs, about nine weeks old, and divided into two lots of six each. Lot I was fed ground wheat and skim milk. Lot II, corn meal and gluten in the proportions mentioned above with the same amount of skim milk as Lot I. Twenty-six pounds of skim milk was fed to each lot night and morning until about the 10th of January when the milk was increased to fifty-two pounds at each feeding. Each lot was fed the food indicated until October 10th when the pigs were weighed and the records of the experiment began. The following table gives the total weight, the average weight and the average monthly gain for each lot until February 11th, the time of slaughtering.

TABLE I — RECORD OF GROWTH AND GRAIN.

DATE OF WEIGHING.	LOT 1 — WHEAT.			LOT 2 — CORN MEAL AND GLUTEN.		
	Total weight.	Average weight.	Average gain.	Total weight.	Average weight.	Average gain.
October 10..........	367	61.1	....	394	65.7	....
November 9.........	628	104.6	43.5	704	117.3	59.8
December 10........	966	161.0	56.4	1,082	180.3	63.0
January 10..........	1,294	215.6	54.6	1,413	235.5	55.2
February 11.........	1,556	259.3	33.9	1,701	283.5	48.0
Total gain.......	1,189	......	......	1,307	......	.....

It will be noticed that the greatest difference in the record of growth of these two lots is the greater gain of Lot II. While the greatest gain of each lot was made during the second month of the experiment, the wheat-fed lot gained nearly as much during the third month as it did during the second month, but the corn-fed lot showed a marked falling off during this time. The difference of growth of these two lots is most marked in the difference of gain; the time when the greatest growth was made was nearly the same for the two lots.

During the time of feeding (from October 10, 1894, to February 11, 1895,) each lot consumed 8,110 pounds of milk, or about 10 pounds per head per day for the whole time. Lot I consumed 3,473 pounds of ground wheat and Lot II 2,826 pounds of corn meal and 735 pounds of gluten feed.

The grain food of these two lots was fed with the milk; the meal and ground wheat was stirred in the milk and fed as a slop. The grain was given in as large quantities as would be readily consumed, and varied somewhat from day to day, no record being kept of the amount consumed daily. Water was kept before each lot nearly all of the time, no record being kept of the amount drank.

The following table gives the live weight, dressed weight and the weight of various organs:

TABLE II — LOT I.

NUMBER OF PIG.	Weight alive.	Weight dead.	Weight dressed.	Weight blood.	Weight heart.	Weight liver.	Weight lungs.	Weight spleen.	Weight stomach and intestines.
1	262.5	255.5	222.00	7.0	.50	3.40	2.60	.34	26.66
2	217.5	212.5	189.00	4.0	.50	2.83	2.31	.21	18.65
3	256.0	249.5	217.00	6.5	.60	3.48	2.82	.30	25.30
4	271.0	265.5	231.00	5.5	.68	4.10	3.04	.28	26.40
5	275.5	271.0	237.00	4.5	.58	3.98	3.00	.32	26.12
6	273.5	267.5	235.00	6.0	.72	4.04	2.96	.34	24.44
Average	259.3	253.6	221.83	5.583	.596	3.64	2.79	.298	24.595
Per 100 lbs. live weight	......	97.853	85.54	2.153	.229	1.4038	1.076	.1149	9.485

TABLE II — LOT II.

NUMBER OF PIG.	Weight alive.	Weight dead.	Weight dressed.	Weight blood.	Weight heart.	Weight liver.	Weight lungs.	Weight spleen.	Weight stomach and intestines.
7	221	218.5	188.00	2.50	.50	2.90	2.50	.40	24.20
8	319	313.0	270.00	6.00	.64	3.94	3.50	.30	34.62
9	315	308.0	272.00	7.00	.68	3.20	2.52	.40	29.20
10	281	273.0	236.00	8.00	.46	3.20	2.70	.19	30.45
11	260	255.0	226.00	5.00	.36	3.00	2.30	.14	23.20
12	305	297.0	259.00	8.00	.40	3.30	3.14	.14	31.02
Average	283.5	277.4	241.83	6.08	.51	3.26	2.78	.26	28.78
Per 100 lbs. live weight	......	97.853	85.301	2.145	.179	1.15	.98	.091	10.155

The total dressed weight of Lot I was 1,331 pounds and the average loss in dressing was 14.46 per cent. On the supposition that the pigs at the beginning of the experiment would lose the same per cent. in dressing as the average of all the lots at the time of slaughtering (16.04 per cent.), there was produced during the time of the experiment 1022.87 pounds of pork. The cost of the grain fed this lot was $38.20, that is allowing 60 cents per bushel for the wheat and 10 cents per cwt. for grinding. Allowing the milk to be worth 15 cents per cwt., the total cost was $50.37, or $.049 per pound for the pork.

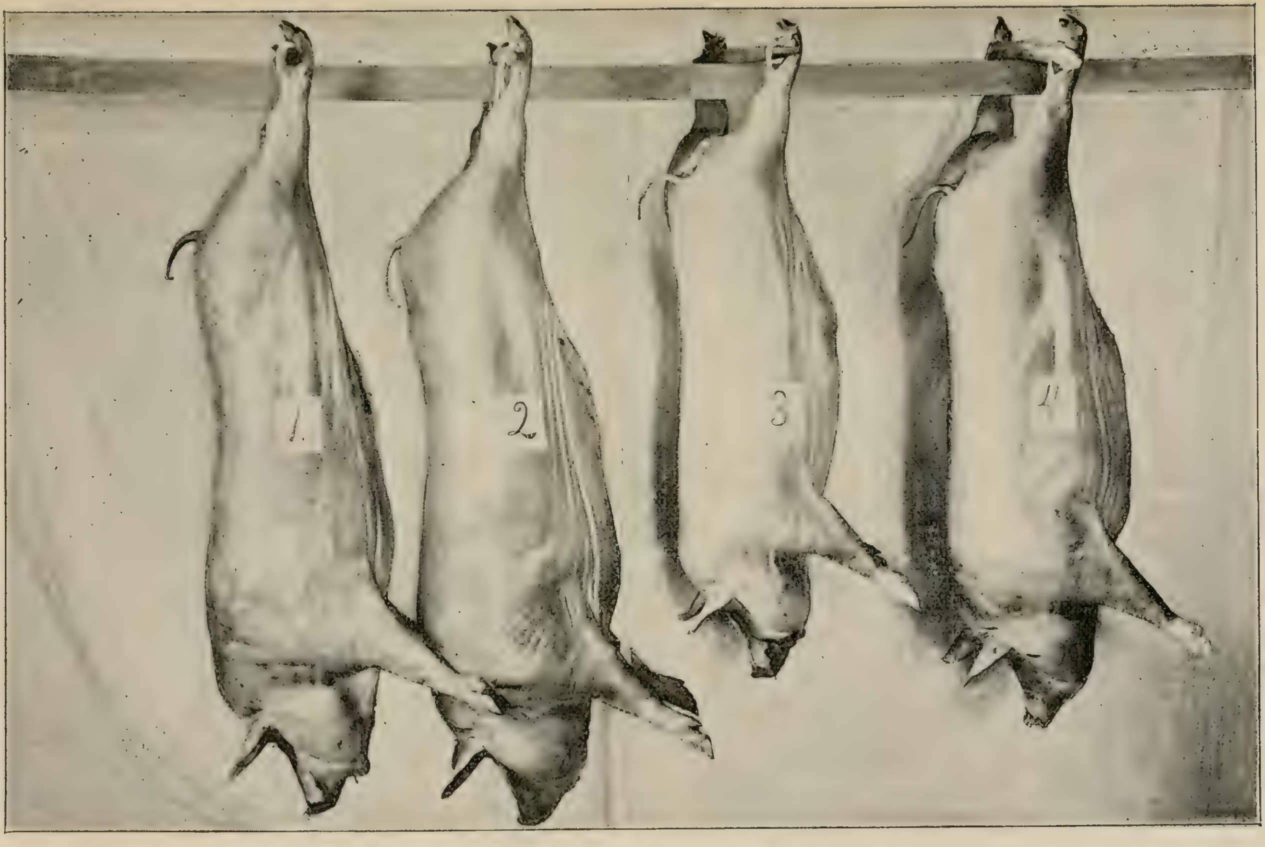
During the same time and on the same basis Lot II produced 1120.20 pounds of pork at a cost of $.0456 per pound. The corn meal was computed at $23 per ton, the average price for which it sold during this time at the Ithaca mills. Gluten meal was purchased at $17.50 per ton delivered at Ithaca. It must be remembered that the above calculations are made on the market prices of grain during the experiment and that the price of wheat was unusually low, while the price of corn was considerably above the average for the last four or five years for which it has been sold in the market. Notwithstanding all this, the corn produced pork at a less cost per pound than did the wheat.

In the illustrations, No. 1 represents Pig No. 1 of Lot I and No. 2 represents Pig No. 12 of Lot II. It will be observed that Pig No. 1 represented almost exactly the average in weight for Lot I, and that Pig No. 12 was only a little heavier than the average for Lot II.

From the same lot of pigs from which Lots I and II were taken twelve more were selected and divided into two lots of six each, making the two lots as nearly alike as possible and numbered Lots III and IV.

Lot III was fed corn meal and water, no other food being given from October 10, 1894 to February 10, 1895, the time of slaughtering.

Lot IV was fed two parts corn meal, one part meat scrap, and water. Lots III and IV were the same age and breeding as those described in the previous experiment. The object in feeding these two lots was to compare nitrogenous and carbonaceous rations as a food for pigs, both as to growth of the animals and the comparative amount of lean meat produced by these foods. As these animals were of the same age and breeding, and about the same weight at



34.— Pig feed (1) wheat, (2) corn meal and gluten, (3) corn meal, (4) corn meal and meat scrap.

the beginning of the feeding as the two lots just described, comparisons may also be made with them.

The following records give the growth and gain of Lots III and IV:

TABLE III.

DATE.	LOT III — CORN MEAL.			LOT IV — CORN MEAL AND MEAT SCRAP.		
	Total weight.	Average weight.	Average gain.	Total weight.	Average weight.	Average gain.
October 10........	383	63.8	....	384	64.0	.....
November 9........	572	95.3	31.5	613	102.0	38.0
December 10........	737	122.8	27.5	883	147.0	45.0
January 10........	885	147.5	24.7	1185	197.5	50.5
February 11........	1003	167.2	19.7	1421	236.8	49.3
Total gain	620	....	....	1037	....	.....

From the preceding tables it will be seen that there was great difference in the growth of the two lots; also in the time when the greatest growth was made. Lot III gained the most the first month of the experiment, and each succeeding month the increase in weight was less than for the month before. Although these pigs ate much less food than Lot IV, yet there was no time when they did not present a thrifty appearance. While they did not make the growth of the other lots, they did not at any time appear stunted or unhealthy.

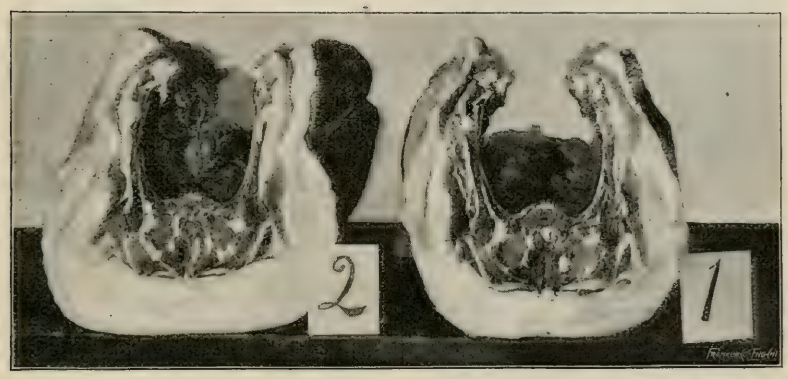
The following tables give in pounds the live weight, dressed weight, and the weight of various organs at the time of slaughtering:

TABLE IV — LOT III.

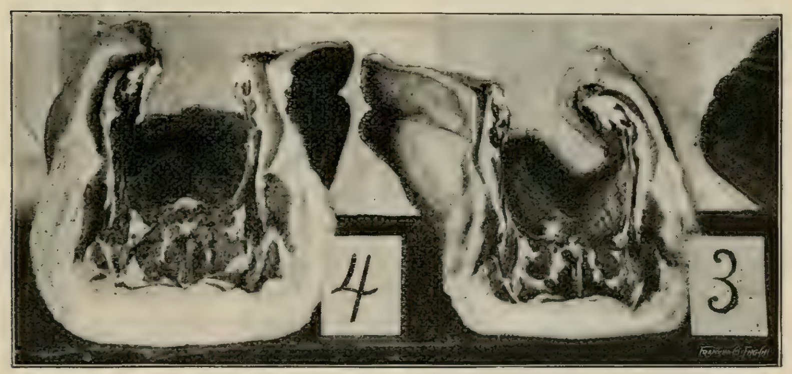
NUMBER OF PIG.	Weight alive.	Weight dead.	Weight dressed.	Weight blood.	Weight heart.	Weight liver.	Weight lungs.	Weight spleen.	Weight stomach and intestines.
19	194.00	189.50	161.00	4.50	.54	2.64	2.08	.36	22.88
20	167.00	162.00	134.00	5.00	.60	2.06	1.58	.30	23.46
21	150.00	145.00	119.00	5.00	.40	2.30	1.60	.30	21.40
22	167.00	162.00	138.00	5.00	.44	2.10	1.48	.29	19.69
23	147.00	143.00	116.00	4.00	.42	1.96	1.38	.28	22.96
24	178.00	175.00	149.00	3.00	.60	2.78	1.48	.38	20.76
Average	167.16	162.74	136.16	4.41	.50	2.31	1.60	.32	21.86
Per 100 lbs. live weight	......	......	81.45	2.632	.299	1.381	.956	.191	13.07

TABLE IV — LOT IV.

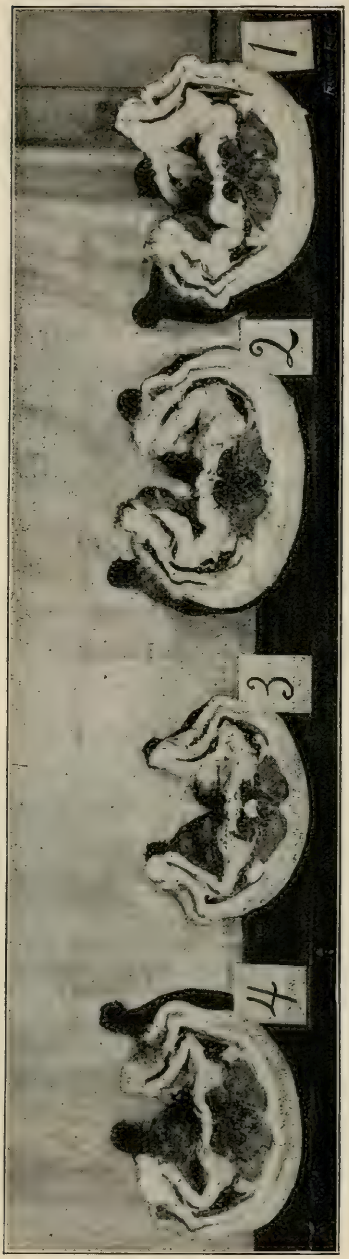
NUMBER OF PIG.	Weight dressed.	Weight dead.	Weight alive.	Weight blood.	Weight heart.	Weight liver.	Weight lungs.	Weight spleen.	Weight stomach and intestines.
13	258.00	252.00	216.00	6.00	.62	4.08	2.60	.34	28.36
14	232.00	228.00	195.00	4.00	.62	3.40	2.00	.40	26.58
15	237.00	233.00	197.00	4.00	.82	4.20	3.22	.50	27.26
16	224.50	219.50	188.00	5.00	.70	2.74	2.50	.40	25.16
17	222.00	215.00	186.00	7.00	.50	3.36	1.86	.32	22.96
18	248.00	242.00	206.00	6.00	.58	4.29	2.56	.32	28.25
Average	236.92	231.60	198.00	5.33	.64	3.68	2.457	.38	26.43
Per 100 lbs. live weight	......	......	83.572	2.245	.27	1.55	1.03	.16	11.155



35.—(1) Wheat, (2) corn meal and gluten. Sections showing distribution of fat and lean meat between the fourth and fifth ribs.



36.—(4) Corn meal and meat scrap (3) corn meal. Sections through the carcass between fourth and fifth ribs, showing distribution of lean and fat meat.



37.—Sections through the carcass between the kidney and ham, showing the distribution of fat and lean meat.

Lot III consumed 2,639 pounds of corn meal which cost $30.35 and produced dressed pork at $.061 per pound.

Lot IV consumed 2,765 pounds of corn meal and 1,382 pounds of meat scrap and produced pork at $.0686 per pound. The meat scrap fed these pigs was obtained from fertilizer manufacturers and appeared to be ground dried meat with a considerable amount of quite fine bone, and analyzed about 10 per cent. of nitrogen. The excesive cost ($40 per ton) made this an expensive animal food. It was fed in connection with the corn meal, not so much to determine the cost of meat production as the amount and distribution of lean meat compared with that produced by corn meal alone.

The number of the pig or the section in the illustrations designates the number of the lot from which the pig was taken. It will be seen that while lot IV showed somewhat the largest proportion of lean meat, yet the difference was not very marked, showing that, in this case the very different rations so far as the nitrogen was concerned, produced very nearly the same proportion of lean meat.

Fig. 34 shows a representative pig from each lot as they appeared the day after slaughtering. Lot II made the largest growth, and was somewhat the fattest although there was not a marked difference between Lots I and II.

Lot III made the least growth yet was about as fat as the other lots, the greatest difference being in size.

Lot IV while not any fatter than Lot III made a much better growth; particularly was this noticeable in the length of the animals before slaughtering.

Figures 35 and 36 shows sections through the carcasses between the fourth and fifth ribs, and Fig. 37, sections between the kidneys and ham. Of all the sections, number 4 shows somewhat the largest proportions of lean meat.

CONCLUSIONS.

Corn meal and gluten gave the greatest growth and produced cheaper pork than ground wheat.

Corn meal and meat scrap produced a somewhat larger proportion of lean meat than did corn meal.

The corn meal and gluten lot had a better appetite and consumed more food than the lot fed ground wheat.

The corn meal lot consumed the least food and made the least growth.

Corn meal and meat scrap produced the largest proportion of lean meat, but not enough more to make it commensurate to the cost of the food consumed.

GEORGE C. WATSON.

BULLETIN 90—April, 1895.

Cornell University—Agricultural Experiment Station.
HORTICULTURAL DIVISION.

THE CHINA ASTERS.

WITH REMARKS UPON FLOWER BEDS.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in Western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.

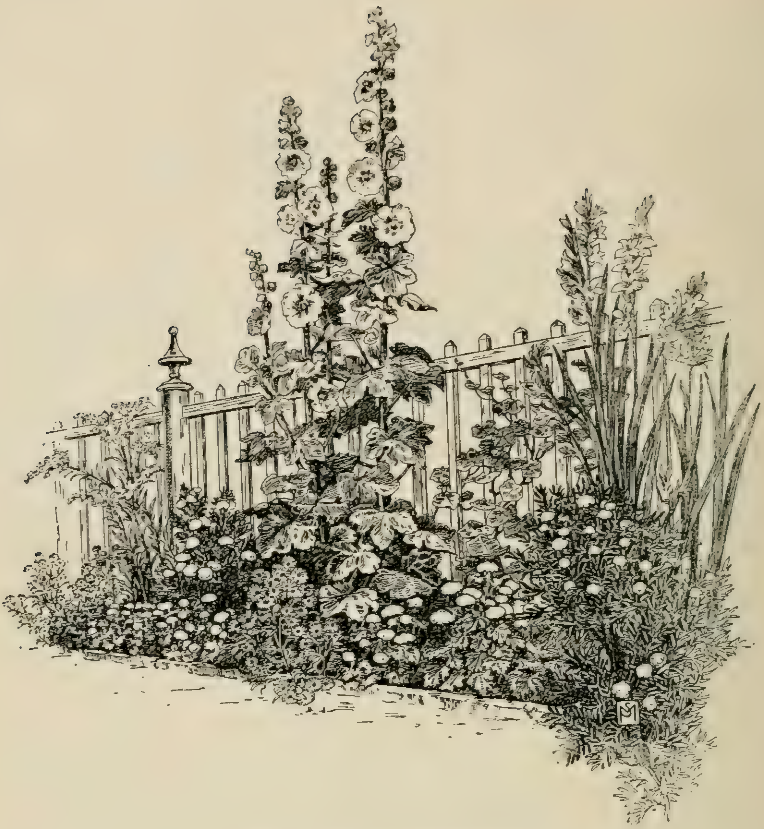
CORNELL UNIVERSITY,
ITHACA, N. Y., *April* 10, 1895.

The Honorable Commissioner of Agriculture, Albany:

SIR.— Last year this station published a bulletin upon the Cultivated Poplars, with some homeopathic remarks respecting the planting of grounds. It was a departure in our work, although it is clearly within the purview of the federal law that matters of ornamental gardening may receive attention from the experiment stations. A full edition of the bulletin was published, but it was very soon exhausted by the demands of correspondents, whilst the surplus of other bulletins touching upon matters of more immediate economic importance, still remained upon our shelves. The people are evidently interested in matters of taste.

Every rural home is touched by any message which is designed to add to the cheer and contentment of life, and with this conviction I have prepared the following paper. I have ventured to prescribe an allopathic treatment for the dejected conventional flower bed of farmers' yards. The outlook of the paper is not wholly upon the sentimental side, however, although I have endeavored to treat the subject from the point of view of the amateur or flower lover. Persons who sell seeds and plants — and their number is legion in western New York — are commercially interested in every effort which aims to extend a love of planting; and persons who buy flower seed are as much in need of advice as those who buy turnip seeds. The account is submitted, therefore, for publication and distribution under Chapter 230, of the Laws of 1895.

L. H. BAILEY.



38.—An Artist's Flower Border.

The chief beauty of the garden should lie in its flower colors and plant forms, and not in the symmetry of its beds and borders. If our ideas of a perfect garden include any rigid geometrical principles, we would better study nature and let our ideals go! Our ideals, at best, are extremely limited, while nature's realism is immeasurable; she puts so much variety into her reality that she is more beautiful than we can imagine, by sheer force of quantity! * * * We should seek to display the whiteness and purity of the lily in the garden, and not trouble ourselves so much about the brown earth patch from which it grows.—*F. Schuyler Mathews, in the Beautiful Flower Garden.*

The China Asters.

WITH REMARKS UPON FLOWER BEDS.

It is commonly assumed that may people have no love or appreciation of flowers, but it is probably nearer to the truth to say that no person is wholly lacking in this respect. Even those persons who declare that they care nothing for flowers, are generally deceived by their dislike of flower-beds and the conventional methods of flower-growing. I know many people who stoutly deny any liking for flowers, but who, nevertheless, are rejoiced with the blossoming of the orchards and the purple bloom of the clover fields. The fault is not so much with the persons themselves as with the methods of growing and displaying the flowers.

The greatest fault with our flower growing is the stinginess of it. We grow our flowers as if they were the choicest rareties, to be coddled in a hotbed or under a bell jar, and then to be exhibited as single specimens in some little pinched and ridiculous hole cut in the turf, or perched upon an ant-hill which some gardener has laboriously heaped upon a lawn. Nature, on the other hand, grows her flowers in the most luxurious abandon, and you can pick an armful without offense. She grows her flowers in earnest, as a man grows a crop of corn. You can revel in the color and the fragrance, and be satisfied.

The next fault with our flower growing is the flower bed. Now, nature has no time to make flower beds; she is busy growing flowers. And, then, if she were given to flower beds, the whole effect would be lost, for she could no longer be luxurious and wanton, and if a flower were picked her whole scheme might be upset. Imagine a geranium bed or a coleus bed, with its wonderful "design," set out into a wood or in a free and open landscape! Even the birds would laugh at it!

What I want to say is that we should grow flowers when we make a flower garden. Have enough of them to make it worth the effort.

I sympathize with the man who likes sunflowers. There is enough of them to be worth looking at. They fill the eye. Now show this man ten square feet of pinks, or asters, or daisies, all growing free and easy, and he will tell you that he likes them. All this has a particular application to the farmer. He grows potatoes and buckwheat and weeds by the acre; two or three unhappy pinks or geraniums are not enough to make an impression.

I suppose that everyone feels that the greatest charm of any landscape in the north is the greensward. It is the canvas upon which every artist planter attempts to make a picture. But imagine a painter putting a glowing bed of coleuses on his canvas, for a centerpiece! The fact is, the easiest way to spoil a good lawn is to put a flower-bed in it; and the most effective way in which to show off flowers to the least advantage is to plant them in a bed in the greensward. Lawns should be large, free and generous, but the more they are cut up and worried with trivial effects the smaller and meaner they look.

But if we consider these lawn flower beds wholly apart from their surroundings, we must admit that they are at best unsatisfactory. It generally amounts to this, that we have four months of sparse and downcast vegetation, one month of limp and frost bitten plants, and seven months of bare earth or mud. I am not now opposing the carpet beds which professional gardeners make in parks and other museums, but desire to direct my remarks to those humble home made flower beds which are so common in lawns of country and city homes alike. These beds are cut from the good fresh turf, often in the most fantastic designs, and are filled with such plants as the women of the place may be able to carry over in cellars or in the window. The plants themselves may look very well in pots, but when they are turned out of doors they have a sorry time for a month adapting themselves to the sun and winds, and it is generally well on towards midsummer before they begin to cover the earth. During all these weeks they have demanded more time and labor than would have been needed to have cared for a plantation of much greater size, and which would have given flowers every day from the time the birds began to nest in the spring until the last robin had flown in November.

I wish that instead of saying flower bed we might say flower border. Any good place should have its center open. The sides may be more or less confined by plantings of shrubs and trees and many kinds of plants. This border planting sets bounds to the place, making it one's own; it is homelike. The person lives inside his place, not on it. He is not cramped up and jostled by things scattered all over the place, with no purpose or meaning. Along the border, against groups, often by the corners of the residence or in front of porches,—these are places for flowers. When planting do not aim at designs or effects; just have lots of flowers, a variety of them growing luxurantly, as if they could not help it.

I have asked a professional artist, Mr. Mathews, to draw me the kind of a flower bed that he likes. It is shown in Fig. 38, at the beginning of this bulletin. It is a border,—a strip of land two or three feet wide along a fence. This is the place where pig weeds usually grow. Here he has planted marigolds, gladiolus, goldenrod, wild asters, China asters, and—best of all—hollyhocks. Any one would like that flower garden. It has some of that local and indefinable charm which always attaches to an "old-fashioned garden," with its exuberant tangle of form and color. Every yard has some such strip of land along a rear walk or fence or against a building. It is the easiest thing to plant it,—ever so much easier than digging the hideous geranium bed into the center of an inoffensive lawn.

There is no prescribed rule as to what you should put into these flower borders. Put in them the plants you like. Perhaps the greater part of them should be perennials, which come up of themselves every spring and which are hardy and reliable. Wild flowers are particularly effective. Everyone knows that many of the native herbs of woods and glades are more attractive than some of the most prized garden flowers. The greater part of these native flowers grow readily in cultivation, sometimes even in places which, in soil and exposure, are much unlike their native haunts. Many of them make thickening roots, and they may be safely transplanted at any time after the flowers have passed. To most persons, the wild flowers are less known than many exotics which have smaller merit, and the extension of cultivation is constantly tending to annihilate them. Here, then, in the informal flower border, is an opportunity to rescue them. Then one may sow in freely of easy-growing annuals, as marigolds, China asters, petunias and phloxes, and the like. One of the advantages of these borders is that they are always ready to receive more plants, unless they are full. That is, their symmetry is not marred if some plants are pulled out and others are put in. And if the weeds now and then get a start, very little harm is done. Such a border half full of weeds is handsomer than the average well kept geranium bed, because the weeds enjoy growing and the geraniums do not. I have such a border, three feet wide and ninety feet long beside a rear walk. I am putting plants into it every month in the year when the frost is out of the ground. Plants are dug in the woods or fields, whenever I find one which I fancy, even if in July. The tops are cut off, the roots kept moist, and even though the soil is a most unkindly one, most of these much abused plants grow. Such a border has something new and interesting every month of the growing season; and even in the winter the tall clumps of grasses and aster-stems wave their plumes above the snow and are a source of delight to every frolicksome bevy of snowbirds.

The China asters are amongst the best of all the annual garden flowers. They are of the easiest culture, most free of bloom, and comprise a multitude of forms and colors. They are, therefore, admirably adapted to profuse and generous effects in schemes of planting. They are also worthy of wide attention because they are adapted to many of the purposes for which chrysanthemums are grown, and they can be raised to perfection wholly without the use of glass. They attain their best in the decline of the season, from late August till frost, at a time when many of the annuals and the greater part of the perennials are spent and gone. No garden flowers carry such a profusion of bloom and color down to the very closing in of winter. Last fall our aster border still had blooms when the snows fell in November, and when even the wild goldenrods had waned and died.

The evolution of the China aster suggests that of the chrysanthemum at almost every point, and it is, therefore, a history of remarkable variations. The plant is a native to China. It was introduced into Europe about 1731 by R. P. d'Incarville, a Jesuit missionary in China, for whom the genus *Incarvillea* of the Bignonia family was named. At that time it was a single flower; that is, the rays or ligulate florets were of only two to four rows. These rays were blue, voilet or white. The center of the flower (or head) was comprised of very numerous tubular yellowish florets. Philip Miller, the famous gardener botanist of Chelsea, England, received seeds of the single white and red asters in 1731, evidently from

France; and he received the single blue in 1736. In 1752 he obtained seeds of the double red and blue, and in 1753 of the double white. At that time there appear to have been no dwarf forms, for Miller says that the plants grew eighteen inches to two feet high. Martyn, in 1807, says that in addition to these varieties mentioned by Miller there had then appeared a "variegated blue and white" variety. The species was well known to American gardeners at the opening of the century. In 1806, M' Mahon, of Philadelphia, mentioned the "China aster (in sorts)" as one of the desirable garden annuals. Bridgeman, a New York seedsman, offered the China and German asters in 1837 "in numerous and splendid varieties," specifying varieties "*alba*, *rubra*, *cerulea*, *striata*, *purpurea*, etc." In 1845, Eley said that "China and German asters," "are very numerous" in New England.

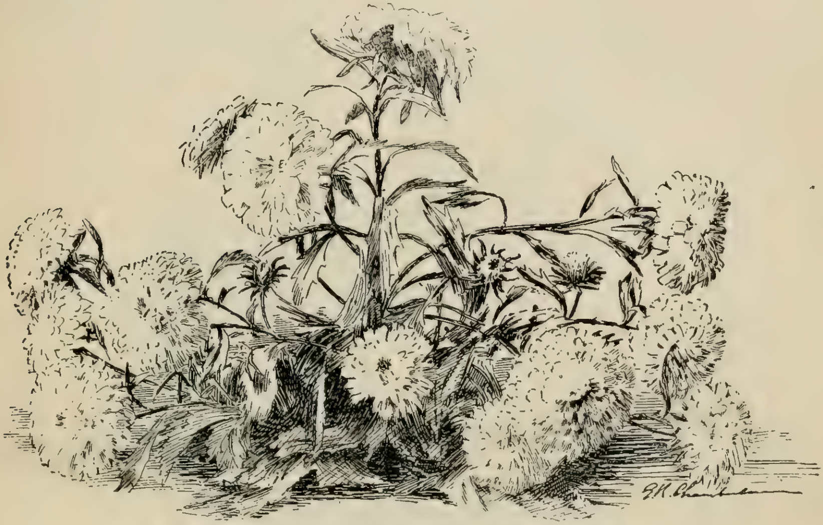
This name German aster records the fact that the first great advances in the evolution of the plant were made in Germany, and the seeds which we now use comes largely from that country. The marked departure from the type, appears to have been the prolongation or great development of the central florets of the head, and the production of the "quilled" flower. This type of aster was very popular forty and fifty years ago. Breck, in the first edition of his "Flower Garden," in 1851, speaks of the great improvement of the aster "within a few years," "by the German florists, and others," and adds that "the full-quilled varieties are the most highly esteemed, having a hemispherical shape, either a pure white, clear blue, purple, rose or deep red; or beautifully mottled, striped, or edged with those colors, or having a red or blue centre." About fifty years ago the habit of the plant had begun to vary considerably, and the progenitors of our modern dwarf races began to attract attention.

The quilled, high centered flower of a generation or more ago is too stiff to satisfy the tastes of these later days, and the many flat-rayed, loose and fluffy races are now most in demand, and their popularity is usually greater the nearer they approach the form of the uncombed chrysanthemums.

The China aster had long since varied into a wide range of colors of the cyanic series — shades of blue, red, pink and purple. I do not know what its original color might have been. The modern evolution of the plant is in the direction of habit, and form of flower. Some type varies — generally rather suddenly and without apparent cause — into some novel form, still retaining its accustomed color. The florist fixes the variation by breeding from the best and most stable plants, and soon other colors appear, until he finally obtains the entire range of color in the species. So it happens that there are various well marked races or types, each of which has its full and independent range of colors. The Comet type (see title page and 3, Fig. 48), now the most deserving of the China asters, illustrates these statements admirably. The Comet form — the loose open flower with the long strap-like rays — appeared upon the market about 1886 or 1887 with a flower of a dull white overlaid with pink. The pink tended to fade out after the flower opened, leaving the color an unwashed white. The rose colored Comet next appeared and the blue was introduced in 1890. The first clear white was introduced in America in 1892, coming from Vilmorian of Paris, and the China aster had reached its greatest artistic perfection.

The greatest desideratum yet to be attained in the China aster is a pure yellow flower. There seems to be some general incompatability between the cyanic and the xanthic, or yellow, series of colors. Yellow of a pure type has not yet been attained in the annual phloxes and many other plants which affect the blues and reds. Yet the chrysanthemum and various other plants combine the two, and I confidently expect that the China aster will eventually do the same. We already have distinct approaches to the yellow in the Lemon Gem, in which the flowers are suffused with a lemon-yellow tint, and in a yellow quilled variety introduced this year by Burpee as the Yellow Aster. This latter aster is one of the crowned type, having a good yellow center and a border of whitish rays.

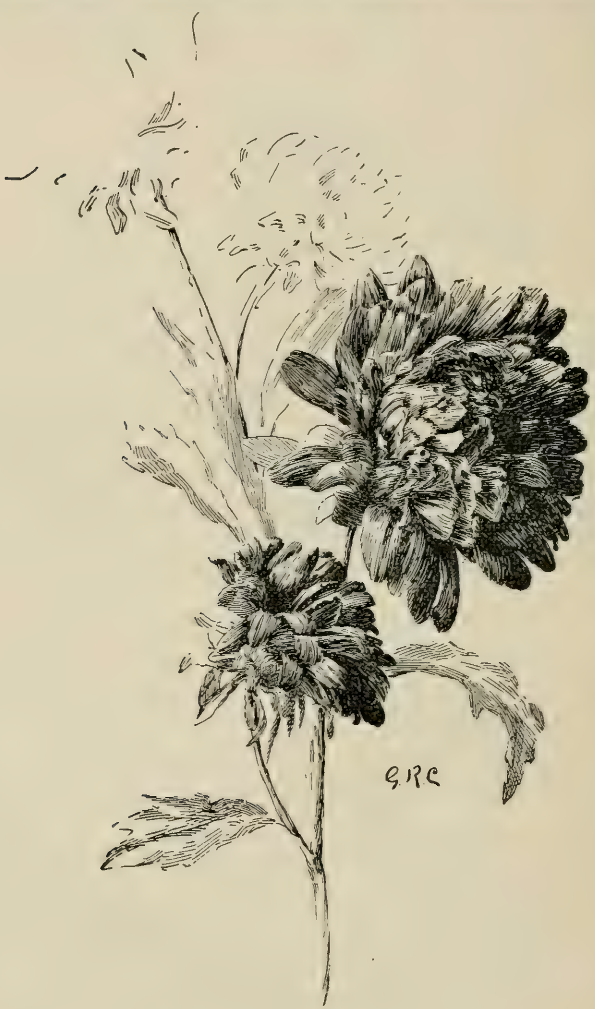
In the immense range of color, form, habit and season in the China aster, the flower lover can find almost any ideal which an annual compositous flower can be expected to satisfy. In earliness, there has been a distinct advance in recent years in the introduction of the excellent French variety, *Reine des Halles*, which is known in this country as Queen of the Market (Fig. 39; 2, Fig. 48.) This variety blooms early in August at Ithaca, even when the seed is sown out of doors. One of the earliest forms of this type of aster is Burpee's Queen of Spring, which will bloom by the middle of July if started in a frame by the middle of April. This *Reine des Halles* type of aster was introduced in 1885 or 1886 by Vilmorin, although it had long been known in the Paris markets, but the stock was controlled by a few persons. This variety also has the freest and most wide spreading habit of growth, and the stems are so long that the variety is very useful for cut flowers. The Candelabra asters are very like the Queen of the Market in habit, but are later.



39.—Queen of the Market. The earliest type of China Aster.

In such a range of type, it is impossible to recommend any one of them as superior to all others. If one wants deep and glowing colors, I should recommend the Truffaut asters, variously known as Perfection and Peony flowered, and this type has a most beautiful pyramidal habit and a high-centered incurved comely flower (Figs. 40, 41). The shades of red are especially good in this type of aster. Closely allied to this is the Semple strain, which has the distinction of being the only well-marked type of American origin. This type originated with James Semple, of Bellevue, Pennsylvania, who, by continued selection, has brought it to a high degree of perfection. The plant is a tall and robust grower, reaching two and a half and even three feet high, with long and strong stems and very large flowers (often three and a half inches across) with incurved and often twisted rays. Two colors of this fine aster are now fixed, the pink introduced in 1892 as Mary Semple, and the white, known as Semple White.

For myself, however, I should give the Comet asters the very first place amongst all the various tribes. The habit is dwarf and compact, although free. But the great merit lies in the flat, soft, spreading long rays, which give the flowers a freedom and novelty of outline and substance which can not be found in any other aster. I am particularly fond of the great white Comet and of the delicate shades of azure blue. I should place the Truffaut, Semple and Jewell strains of asters — all of similar type — in the second place.



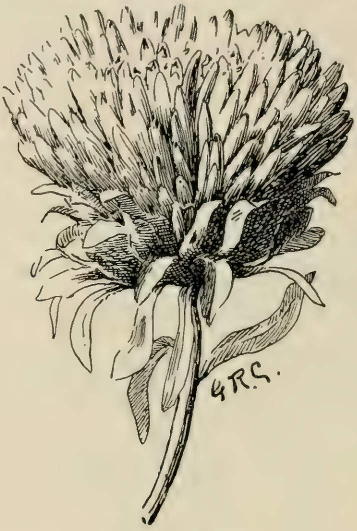
40.—Truffaut's Peony flowered.

The Jewell aster known as Apple Blossom, has no superior amongst the delicate shades of blush or pink. For the third place, I should hesitate between the Washington and Chrysanthemum-flowered types. The Victorias are generally given a very high rank, and they are one of the most popular strains in England, particularly for pot culture, but they have not behaved so well with me. They seem to be untrue and mixed in type, and last year many of them gave flat open "eyes" or centers. Yet I should place the Victorias fourth or fifth in my list. Beyond these types, it would be difficult to single out one strain as superior to others for purposes of general cultivation. All of them have particular merits. The Queen of the Market is desirable for earliness, long stems and graceful habit, and it is popular with florists. The quilled asters are now so far outnumbered by the flat-rayed section that they may almost be classed with the curiosities. They are always useful for variety, and many persons admire their prim form. One of the best of these is the Victoria Needle (Fig. 42), a variety which distinguished itself on our grounds last year by giving the latest blooms of any aster. The Lilliput,— a slim-growing sort with small stiff-petalled flowers — is also one of the favorites of the quilled section. Reading Beauty is also an excellent quilled aster.

41.—Truffaut's Peony-flowered aster.

Another type of quilled aster is represented by the button-headed German Quilled, with its scant fringe or short rays (Fig. 43). The best form of this is the Betteridge, an improved strain with large flowers.

Amongst the curious asters are the Crown or Corcardeau, with a rim of dark color and a center of white or light shades (Figs. 44, 45), the Harlequin or party-colored, and the many miniature or tufted sorts, some of which grow only three or four inches high, and bear a close bunch of small dense flowers (see Fig. 47). The very dwarf types are stiff and bunchy, but they are often used for borders, and the plants can be lifted on the approach of frost and put in pots, where they will continue to hold their flowers for three or four weeks.



42.—Victoria Needle.

It is impossible to construct a satisfactory classification of the China asters. It is no longer practicable to classify the varieties by color. Neither is it feasible to classify them upon habit or stature of plant, for several of the best marked types run into both tall and dwarf forms. Vilmorin, however, still divides the varieties into two groups, the pyramidal growers, and the non-pyramidal growers.* The most elaborate classification is that proposed by Barron, from a study of extensive tests made at Chiswick, England.† Mr. Barron

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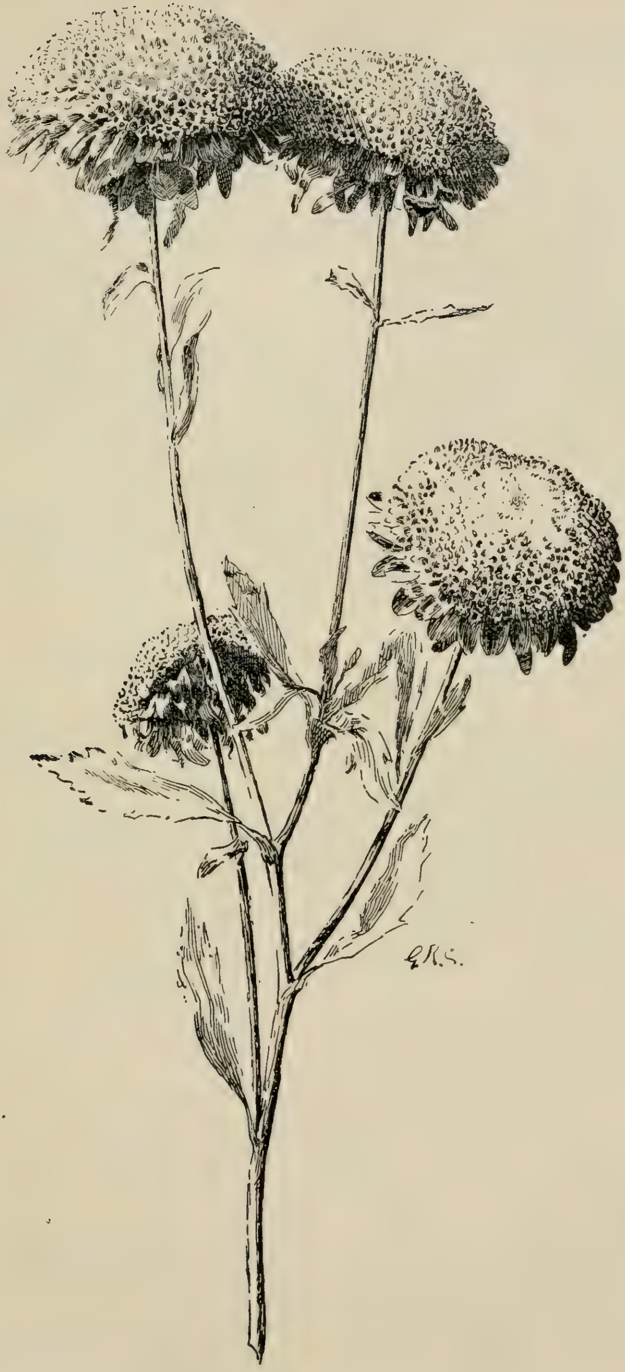
* Les Fleurs de Pleine Terre, 4th ed. 856 (1894).

† Journal Roy. Hort. Soc. xi, part i, 15 (1889) ; xii, part ii, 401 (1890).



43 — German Quilled Aster.

has seventeen sections, but they are not co-ordinate, and they are really little more than an enumeration of the various types or classes. After considerable study of the varieties in the field and herbarium, I find the following scheme to be the most serviceable for my purpose:

I. Flat-rayed asters, in which all, or at least more than five or six rows of rays, are more or less prominently flat and the florets open.

A. Incurved or ball shaped.

B. Spreading or reflexed.

II. Tubular or quilled asters, in which all, or all but the two or three outer rows of florets have prominently tubular corollas.

A. Inner florets short; outer ones longer and flat. Represented by the German Quilled.

B. All the florets elongated and quilled.

I shall make no attempt to describe all the China asters now offered by American seedsmen, nor even all that we have grown, but the following running notes may have some interest:

I. A. *Globe Asters.*

Truffaut, Peony-flowered or Perfection Asters (Figs. 40, 41, 4 in Fig. 48).—This is one of the oldest types of our modern asters, having been known—although probably not in its present excellence—nearly or quite fifty years ago. It was developed by Truffaut of Versailles, who died early in the present year when 78 years of age. The plants are moderately tall, strong and vigorous, more or less pyramidal in habit, with nearly globular often nodding large flowers with the outer petals generally spreading or loose. In many colors. La Superbe is one of the best strains. There is a semi-dwarf form which is excellent. Prince of Wales is one of the globe-flowered Truffauts.

Semple.— Already described, page 219. The New Branching Aster seems to be the same.

Ball-flowered or Jewell.— Mostly of dwarfer habit than Semple, the flowers less incurved than Truffaut, the petals short and the blooms compact and firm. Various colors. Excellent for symmetry of bloom.

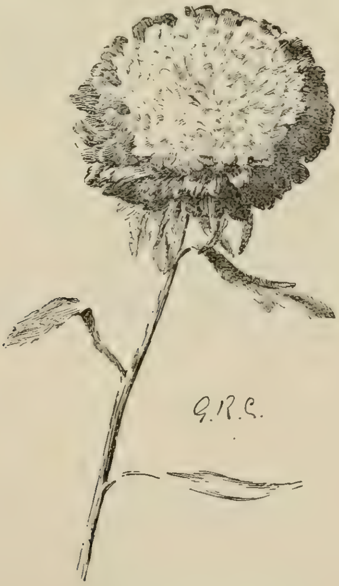
Triumph.— As originally introduced by Haage and Schmidt, about 1887, this is a dwarf peony-flowered aster, but much of it now seems to be open-flowered, and Barron classes it with the Chrysanthemum-flowered types. When pure, it is one of the best of the dwarf asters, but it does not appear to be well fixed. It has a very free and graceful habit for a dwarf. Height about eight or ten inches.

I. B. *Flat or Reflexed Asters.*

Chrysanthemum-flowered (1 in Fig 48).— Plants of various habit and of various merits. Usually characterized by a free and open growth, although there are semi-dwarf forms, and symmetrical well-formed flowers with the outer rays much reflexed. A very useful class, in many colors.

Washington.— An offshoot of the last, of medium height, with large, rather flattish flowers, full and symmetrical to the center. Many colors, and little inclined to "run" or sport.

Mignon.— A very fine aster, of medium height, close, pleasing habit, the flower full to the center and rather flat, the lower rays not much reflexed. A most interesting feature of one variety is its singular habit of changing color. It opens a white flower with only the faintest tinge of undefinable azure or flesh color, but gradually passes into a delicate light rose pink. Flowers small and more regular in shape than the Victorias.



44.—Crown Aster.

Victoria.—A very popular class of asters, both tall and dwarf. It is commended for its very free blooming, and for the habits of many of the white strains of changing into azure and pink tints, like the Mignon. (Page 151.)

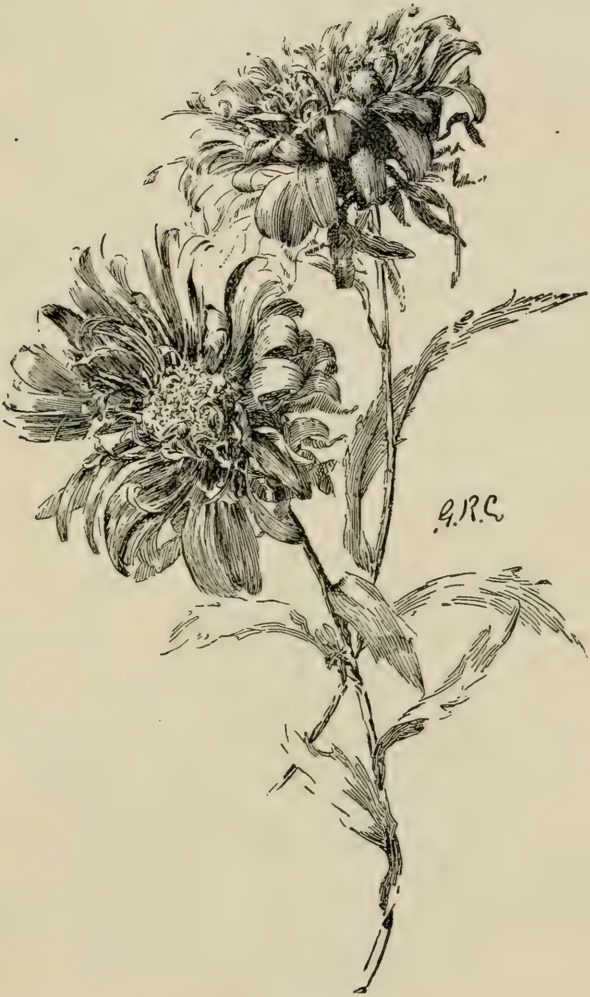
Emporer or *Giant Emporer.*— A strong tall grower, rather late, only slightly branching and bearing three to five very large flowers, of chrysanthemum form; various colors.

Queen of the Market (Figs. 39, 2 in Fig. 48) has been already described (pages 149, 151). Queen of Spring and Queen of the Earlies are varieties of this type.

Crown or *Corcardeau* (Figs. 44, 45).— Of medium or semi-dwarf habit (45), early and free flowering. Center of the flower white or nearly so, surrounded by a rim or fringe of variously-colored rays. Interesting and very showy. The central florets are somewhat tubular, and suggest the quilled section of asters, with which, perhaps, the type should be classed. Known also as Double Crowned, Pompon Crown and Cockade.

45.— Crown.

Comet (Title page, illustration, Fig. 46, 3 in Fig. 48).— Fully described on pages 148, 150. The center of the flower is filled with



46.—Comet, inferior type.

short rays, which are sometimes very narrow and twisted. The type still tends to sport, although the greater part of the flowers come true to the ideal form. Fig 46 shows one of the most frequent departures from the type, with a loose border and a "single" center. In this form the variety approaches chrysanthemum flowered type The Comet asters, in various colors, are amongst the best of all the races for flower border, but they are less useful for cut flowers than some of the larger stemmed and stiffer and rounder flowered types, like Truffaut, Semple, Ball-flowered and the like.

Imbricated or *Imbricated Pompon.*— This aster, in many colors, is intermediate between the flat-rayed and quilled sections. The rays are all alike or approximately so, short and somewhat concave, springing from a tubular base. The flowers are medium or sometimes small in size, very close and compact, and uniform in shape. The habit is compact, either dwarf or rather tall. Distinct and desirable.

II. A. *Button-quilled asters.*

German quilled (Fig. 43). — Described on page 223. There are many excellent strains of this type, mostly of medium tall and spreading growth, with long stiff stems. In some forms, the flowers are drooping. Many colors.

Dwarf Bouquet (Fig. 47). — Very dwarf and compact asters, growing five to eight inches high, with a terminal bouquet of small very dense flowers with the center florets short and tubular, and a thin border of short flattish rays. Excellent for borders, or formal effects. Many colors.

47.— Dwarf Bouquet.

Shakespeare.— Much like the last, but the flowers more distinctly quilled. These are the dwarfest asters which we have grown, many of the plants never reaching beyond four inches in height. Many colors.

II. B. *Long-quilled or Needle asters.*

Victoria Needle (Fig. 42).— Either medium tall or dwarf asters, with the habit of the Chrysanthemum-flowered type, and the range and brilliancy of coloring of the Victorias, but distinguished by the long quill-like florets, and the absence of rays. Excellent, of its class. (Page 222.)

Lilliput.— Plants tall and strict. Flowers small, the quills slender and compact. Late. Many colors, very pretty. (Page 221.)

The student a few years hence who consults this paper — if I should be so fortunate as to have a reader then—will be interested to know just what varieties of asters were offered by American seedsmen in the spring of 1895. I have, therefore, made a list of the varieties, under the names by which they are catalogued. All these many and various types belong to a single species (*Callistephus hortensis*[*]), which is native to Siberia and China, and which is now widely cultivated in temperate climates. The trade names are given, without any attempt to determine synonyms:

Alneer's Perfection Double.
Ball of Fire.
Betteridge's Prize.
Betteridge's Quilled, Mixed.
Betteridge's Quilled, Sulphur Yellow.
Blue Danube.
Bolitze's Dwarf Bouquet.
Boston Florists' White.
Boston Market White.
Bouquet Dwarf, Crimson.
Bouquet Dwarf, Mixed.
Bouquet Dwarf, White.
Branching, Crimson.
Branching, Lavender.
Branching, Shell Pink.
Branching, White.
Breck's International Prize.
Candelabra, Red.
Caldelabra, Rose.
Candelabra, White.
China.
Chrysanthemum flowered — Dwarf, Brilliant Rose.
Chrys. flowered — Dwarf, Crimson.
Chrys. flowered — Dwarf, Dark, Lavender.
Chrys. flowered — Dwarf, Fiery Scarlet.
Chrys. flowered — Dwarf, Flesh Pink.

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[*] The proper botanical name of the China aster, however, is *Callistemma hortense*, Cassini, Dist. Sci. Nat. vi. Suppl. 45 (1817), and Bull. Soc. Philom. 1817, 32. The name *Callistephus hortensis*, both genus and species, dates from 1825. This latter name is accepted by Bentham and Hooker, however (Genera Plantarum, ii, 270), and I therefore used it in the revision of Gray's Field, Forest and Garden Botany, inasmuch as Gray preferred to adhere closely to Bentham and Hooker's work. *Callistemma* has long been in use, with more or less frequency, by horticulturists, and it would seem, therefore, that it should be revived.

Chrys. flowered—Dwarf, Indigo Blue.
Chrys. flowered—Dwarf, Large Flowered.
Chrys. flowered—Dwarf, Light Blue.
Chrys. flowered—Dwarf, Orange Rose.
Chrys. flowered—Dwarf, Mixed.
Chrys. flowered—Dwarf, Rose.
Chrys. flowered—Dwarf, Striped.
Chrys. flowered—Dwarf, White.
Chrys. flowered—Tall, Mixed.
Cocardeau or Crown.
Comet, Bright Blue and White.
Comet, Carmine.
Comet, Deep Pink.
Comet, Dwarf.
Comet, Giant White.
Comet, Indigo and White.
Comet, Lavender and White.
Comet, Light Blue.
Comet, Lilac.
Comet, Lilac and White.
Comet, Mixed.
Comet, Peach Blossom.
Comet, Pink and White.
Comet, Purple White.
Comet, Rose.
Comet, Rose and White.
Comet, Snow White.
Crimson Crown.
Crimson Wave.
Diamond.
Diamond, Dark Crimson.
Diamond, Deep Carmine.
Diamond, Deep Violet.
Diamond, Deep Violet and White.
Diamond, Crimson and White.
Diamond, Pink and White.
Diamond, Purplish Lilac.
Diamond, Reddish Violet.
Diamond, Rose.
Diamond, White.
Double German.
Dwarf, Brilliant Rose.
Dwarf, Fiery Scarlet.
Dwarf German
Dwarf Pyramidal.
Dwarf Pyramidal Bouquet.
Dwarf Queen.
Dwarf Queen, Crimson.
Dwarf Queen, Dark Blue.
Dwarf Queen, Large Flowering.
Dwarf Queen, Light Blue.
Dwarf Queen, White.
Eclipse.
Empress, Bright Blue.
Empress, Crimson.
Empress, Mixed.
Empress, White.
French, Peony.
General Jacqueminot.
Giant Emperor.
Globe Flowered, Double German.
Globe Flowered, Pyramidal.
Goliath.
Half Dwarf, Multiflora Mauve.
Harlequin, Mixed.
Henderson's Marvel.
Hovey's Florist's Prize.
Imbricated Pompon, Crimson.
Imbricated Pompon, Dark Indigo.
Imbricated Pompon, Lavender Blue.
Imbricated Pompon, Mixed.
Imbricated Pompon, "Mourning Aster."
Imbricated Pompon, Rose.
Imbricated Pompon, Sky Blue.
Imbricated Pompon, White.
Improved Pyramidal Bouquet.
Improved Quilled.
Improved Victoria.
Jewel, Apple Blossom.
Jewel, Carmine Rose.
Jewel, Crimson.
Jewel, Purple.
La Brilliant.
Lady in White.
Large Rose Flowered, Dark Scarlet.
Large Rose Flowered, Mixed.
La Superbe.
Lemon Gem.
Leonard's Snowball.

Lilliput-flowered, White.
May's Miniature.
Meteor, Bright Crimson.
Mignon.
Mignon, Bright Blue.
Mignon, Carmine Red.
Mignon, Peach Blossom Pink.
Mignon, Snow White.
Mignon, White and Lilac.
Mignon, White and Rose.
Miniature Bouquet.
Mixed Crown.
New Dwarf Pearl.
Ne Plus Ultra.
Pearl.
Pearl Blanche.
Pearl Rose Crown.
Pearl Rouge.
Perfection, Flesh-colored.
Perfection, Light Yellow.
Primrose Pink.
Prince of Wales.
Princess Rosalind.
Pygmæ.
Pyramidal Harlequin, Purple.
Queen of Spring.
Queen of the Earlies.
Queen of the Market.
Quilled, or China.
Reid's German Quilled.
Reine des Halles.
Rose.
Rose, Blue.
Rose, Dark Red.
Rose, White.
Rose-flowered.
St. Paul Beauty.
Salzer's Goliath.
Salzer's Prize Bouquet.
Salzer's White Bouquet.
Scarlet Needle.
Schiller, White.
Semple's Branching.
Shakespeare, Crimson.
Shakespeare, Dark Blue.
Shakespeare, Mixed.
Shakespeare, White.
Silver Ball.
Snowball.
Snow Queen.
Sulphur Yellow.
Sutton's Reading Beauty.
Triumph, Dark Scarlet.
Triumph, Dark Scarlet and White.
Triumph of the Market.
Truffaut's Peony Perfection, Brilliant Rose.
Truffaut's Peony Perfection, Carmine.
Truffaut's Peony Perfection, Crimson.
Truffaut's Peony Perfection, Dark Blood Red.
Truffaut's Peony Perfection, Deep Mauve.
Truffaut's Peony Perfection, Light Blue.
Truffaut's Peony Perfection, Mixed.
Truffaut's Peony Perfection, Pink.
Truffaut's Peony Perfection, Purple.
Truffaut's Peony Perfection, Snow White.
Truffaut's Peony Perfection, Striped.
Truffaut's Peony Perfection, Dwarf, Black Blue.
Truffaut's Peony Perfection, Dwarf, Black Blue and White.
Truffaut's Peony Perfection, Dwarf, Crimson and White.
Truffaut's Peony Perfection, Dwarf, Light Blue.
Truffaut's Peony Perfection, Dwarf, Light Blue and White.
Truffaut's Peony Perfection, Dwarf, Rose.
Truffaut's Peony Perfection, Dwarf, Rose and White.
Truffaut's Peony Perfection, Dwarf, Shining Dark Scarlet.
Truffuat's Peony Perfection, Dwarf, White.
Uhland Globe.
Vaughan's Beauty.

Vaughan's Fireball.
Vaughan's Improved Victoria.
Vesuvius.
Vick's New Branching.
Victoria, Apple Blossom.
Victoria, Bourdeaux Red.
Victoria, Dark Scarlet.
Victoria, Dwarf Bouquet, Crimson.
Victoria, Dwarf Mixed.
Victoria, Dwarf Rose.
Victoria, Dwarf White.
Victoria, Cream Colored.
Victoria, Crimson.
Victoria, Large Flowering.
Victoria, Light Blue.
Victoria, Needle.
Victoria, Needle Perfection.
Victoria, Peach Blossom.
Victoria, Purple.
Victoria, Striped.
Victoria, White.
Washington, Crimson.
Washington, Light Blue.
Washington, Mixed.
Washington, Needle.
Washington, Peach Blossom.
Washington, Silver Gray.
Washington, White.
White Star.
White Wave.
Yellow Aster.
Zirngiebel's, Double White.
Zulu King.

Respecting the cultivation of these China asters, little need be said. If early flowers are wanted or if the plants are to be grown in pots as specimens for exhibition, the seeds should be sown indoors or in a frame as early as the middle of April, in this latitude. But if the plants are to be grown in borders, it is quite as well to sow the seed in the ground where the plants are to grow. The China aster is essentially an autumn flower, and I have no desire, from the amateur's standpoint, to force it ahead of its season and to make it compete with the flowers of midsummer. We sowed the seeds of about fifty varieties on the 4th of June last year. The soil was rich and kindly — a good loam — and the plants came on with vigor, and, notwithstanding a prolonged drought, every variety gave a profuse bloom throughout September and October, and a few sorts — like Queen of the Market — spent themselves and died before frost came.

China asters do not force well. They generally grow too tall and are too slow in coming into bloom. But experiments in forcing them for winter bloom have not been made to any extent in this country, and it is not improbable that some varieties might lend themselves to this treatment with ease.

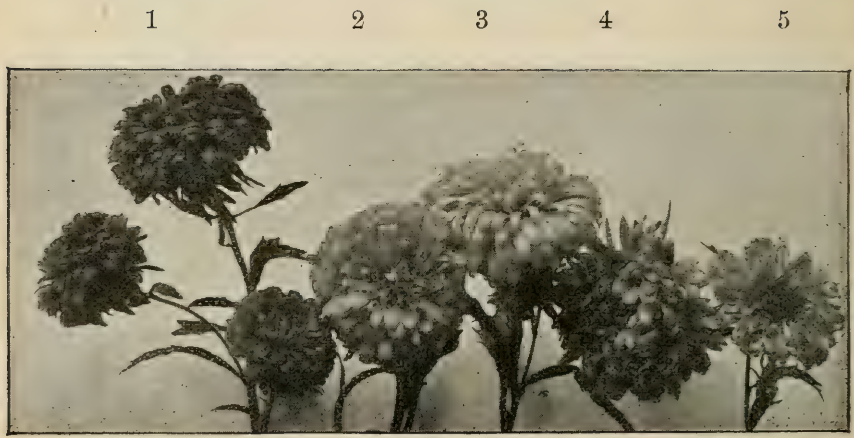
There are two or three insects which prey upon the China aster but they do not appear to be widespread. The most serious difficulty with them is the rust, a fungus (*Coleosdorium Sonchiarvensis*) which attacks the under side of the leaf and raises an orange-colored pustule. Timely sprays with the copper fungicides will keep this disorder in check. The Bordeaux mixture discolors the plants, and it is therefore better to use the ammoniacal carbonate of copper. Spray it upon the plants before the fungus appears, and repeat every week or ten days. Use a cyclone nozzle and spray upwards, so as to strike the under sides of the leaves.

ABSTRACT.

This bulletin desires to discourage the formal and geometrical flower bed, which persists in setting itself into the middle of a quiet and well behaved lawn. It advises that flowers be grown for their own sakes, and not for the bed in which they happen to be placed. It urges the growing of flowers profusely, in a free and graceful way, in borders next rear walks and fences and against groups of larger plants and occasionally about the foundations of buildings. It would use hardy and free-growing plants in preference to the potted and unwilling house plants, which usually give strained and exotic effects.

The China asters are amongst the best of the annuals for popular use: They are essentially autumn flowers, and little is to be gained by forcing them ahead of their season, except when they are wanted for sale as cut flowers. In central New York, they may be sown as late as the first or even the middle of June with good results, if the soil is rich and if they are given good care. There is a multitude of varieties. For growing in borders, perhaps the best type is the Comet, in various colors. Other excellent races are the Truffaut, known also as Perfection and Peony-flowered, the Semple or Branching, Chrysanthemum-flowered, Washington, Victoria and Mignon, and Queen of the Market. The last is commended for earliness and graceful open habit, and it it one of the best for cut flowers. Many other types are valuable for special purposes. The Crown of Cocardeau is odd and attractive. Amongst the quilled asters, the various strains of German Quilled, Victoria Needle and Lilliput are excellent. The very dwarf tufted asters are well represented in Dwarf Bouquet or Dwarf German, and Shakespeare.

L. H. BAILEY.



48—1 (3 flowers), Chrysanthemum-flowered ; 2, Queen of the Market ; 3, Comet ; 4, Truffaut's Peony-flowered ; 5, ye olde tyme sorte.

BULLETIN 91—April, 1895.

Cornell University—Agricultural Experiment Station.

HORTICULTURAL DIVISION.

By Michael Barker.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.

Cornell University,
Ithaca, N. Y., *April* 20, 1895.

The Honorable Commissioner of Agriculture, Albany:

Sir.— The sudden popularization of the chrysanthemum is one of the marvels of recent horticultural enterprise. The commercial interest in chrysanthemum growing in this State is now very large, and there are many features of the industry which demand attention from experimenters. As a beginning towards the solution of some of the perplexities which beset the growers of the plant, and for the purpose of still further popularizing a worthy industry, we have made a careful test of the leading varieties upon the market in 1894, and have here given an account of the behavior of the most prominent ones. Our collection numbered over 200 kinds. The report is written from the point of view of the florist, rather than the amateur. I submit the paper as a bulletin under Chapter 230 of the Laws of 1895.

L. H. BAILEY.

A KEY TO THE CLASSIFICATION OF VARIETIES OF CHRYSANTHEMUMS.

Group A. Large flowered. Diameter 4 to 10 inches.
  Section 1. Incurved.
    Florets regularly incurved.
   Sub-section 1. Japanese Incurved.
    Florets irregularly incurved.
  Section 2. Japanese.
    Florets straight, spreading, twisted, curled, or drooping.
  Section 3. Reflexed.
    Florets regularly reflexed.
   Sub-section 2. Japanese Reflexed.
    Florets irregularly reflexed, or long and drooping.
  Section 4. Anemone.
    Florets in two series, disk and ray. Disk florets tubular, forming half a sphere in center. Ray florets strap-shaped, horizontal and arrayed around the outside.
   Sub-section 3. Japanese Anemone.
    Ray florets incurved, reflexed, or drooping.

Group B. Small flowered or Pompon. Diameter 1 to 2 inches.
  Section 1. Pompon.
    Flowers formal and diminutive, with short closely packed florets.
  Section 2. Anemone Pompon.
    Diminutive flowers of the Anemone type.

Group C. Single flowered. Diameter 1 to 5 inches.
  Flowers single.

Recent Chrysanthemums.

Within the past ten years, the chrysanthemum of the florists has risen from a very inferior position, commercially, to one of the greatest prominence in this country. The first regular chrysanthemum exhibition in America was held under the auspices of the Massachusetts Horticultural Society in 1868, but this and the sister society in Pennsylvania awarded prizes for chrysanthemums much earlier. In those days, however, and perhaps for many years previous, the chrysanthemum was treated as a hardy plant, and cultivated in the outdoor gardens. Better flowers and plants came later, with the idea of affording them greenhouse protection, and then we find Dr. H. P. Walcott, of Cambridge, Massachusetts, and Mr. John Thorpe, then of Queens, Long Island, to be the most prominent raisers of seedlings, cultivators and advocates of the chrysanthemum in general.

But the courageous attempts of these and several other persons in various parts of the country, particularly in the vicinity of Boston, Massachusetts, met with only a small share of success. Not, indeed, until the later years of the past decade was anything approaching popular esteem for the chrysanthemum aroused in the American people, and then it was mainly due to a happy speculation on the part of one of our prominent nurserymen. In 1888, Mr. W. A. Manda, then of Cambridge, Massachusetts, now at South Orange, New Jersey, purchased the famous variety, Mrs. Alpheus Hardy, from a Boston florist for the sum of $1,500 — a price unprecedented in the chrysanthemum world. This event, and the subsequent advertising of the variety, did more to render the chrysanthemum an object of public fame in America than all other previous efforts combined. The demand for these plants at once began to grow with leaps and bounds, annual exhibitions sprung into existence in all parts of the country, and many florists and nurserymen created special departments to cover the work of securing new varieties and to select, propagate and distribute those of greatest merit.

Mrs. Alpheus Hardy had been sent here in the first instance from Japan, and numerous other varieties were now imported from that country in the hope of securing something equally valuable. But while many of those importations proved really meritorious under our climatic conditions, none of them reached that high position in the public regard which had been accorded their forerunner.

So many of these varieties imported from Japan and Europe proved to be unsatisfactory, that it soon became evident that if our growers were to have a class of plants suited to their own peculiar needs and climate, they must set about raising them from seeds, crossing the varieties in hand so as to secure offspring of the desired character. This has been done with very marked success, and foremost among those who have given the departure extensive attention and encouragement may be mentioned, Messrs. Pitcher & Mandy, of Short Hills, New Jersey; Messrs. Nathan Smith & Son, Adrian, Michigan; Messrs. Peter Henderson & Co., New York; Messrs. E. G. Hill & Co., Richmond, Indiana; Mr. John N. May, Summit, New Jersey; Mr. Hugh Graham, Philadelphia; Mr. T. D. Hatfield, Wellesley, Massachusetts; Mr. J. C. Vaughan, Chicago; Mr. Wm. K. Harris, Philadelphia; Mr. Thos. H. Spaulding, Orange, New Jersey, and Messrs. Fred. Dorner & Son, Lafayette, Indiana. A very large proportion of the imported varieties are weak growers, and they have a tendency to produce imperfect flowers. The outer florets (erroneously called petals) sometimes expand so as to show the center of the flower, and this characteristic renders certain groups of varieties comparatively worthless for commercial purposes, while in other sections (anemones and pompon anemones) the full development of this central disk is considered one of the essentials of a worthy bloom. This defect occurs less frequently in the domestic productions, although unscrupulous dealers occasionally praise inferior varieties to the disadvantage and often serious loss of the purchaser. Great difficulty stands in the way of decreasing the extent of this evil. With some such idea, and to prevent the duplication of names, the American Chrysanthemum Society was organized at Buffalo, N. Y., August, 1889; and the work of that body, especially in the latter particular, has been of great service to the growers. A promising innovation was made by the society last autumn in establishing local committees to determine the degree of merit exhibited by all new varieties brought to their notice, and to report them worthy or unworthy, as they found them to be. With a testimonial of this character, given by the most competent judges, the meritorious varieties should soon close the market against all others, and for this reason those who are successful in producing good new kinds should in future submit them to some member of the society before trying to dispose of them by the ordinary process of commerce. The present officers of the society are: Mr. E. A. Wood, Denver, Colorado, president; Mr. E. G. Hill, Richmond, Indiana, vice-president; Mr. E. D. Smith, Adrian, Michigan, secretary; Mr. John N. May, Summit, New Jersey, treasurer.

Great as are the troubles of nomenclature and misrepresentation, there are others of almost equal importance which the society can not properly regulate, and the undertaking would be much too troublesome for private or commercial growers. Many dealers now issue long annual lists of new kinds from which it is impossible to select the best varieties for local requirements. No effort is spared in the most expensive and elaborate system of cultivation, to make these plants produce blooms for the exhibitions of the previous autumn, and the awards then given are at best an imperfect guide for the investor. The average florist for obvious reasons can provide only ordinary conditions, and he desires to know if any of these new varieties will prove better than the older and cheaper sorts under his method of cultivation. Again, some varieties produce the choicest blooms from "crown" buds, while "terminal" buds are the best in others; some bloom late, others early; some are adapted for specimen plants, others for specimen flowers. Then there are new insects and diseases to deal with, and many minor matters bearing on cultivation, the effects of various fertilizers, etc. Hitherto there has been no one to thoroughly investigate these matters for the benefit of the vast number of people throughout the State and country who are financially and otherwise interested. A work of this character has been recently undertaken by the Horticultural Department of Cornell University, and it is hoped in due time to bring about the desired results. Although late in the season, operations were begun last August, and a record of the results so far obtained will be found in these pages. It is due to the public spirit and generosity of Messrs. Pitcher & Manda, Messrs. Peter Henderson & Co., Mr. John N. May, Messrs. Nathan Smith & Sons, and Messrs. E. G. Hill & Co., that we were enabled to secure for our purposes ample supplies of such of their varieties of 1894 as were in stock at that time. Many others, who promised to contribute during the present season, would have joined in the work last year had our intentions been known to them before their supplies were exhausted.

RECENT VARIETIES.

While a large number of the new varieties put on sale in the United States of late years show no marked improvement on older types, there are still many of them decidedly superior in character. The advance is perhaps most noticeable in the stems, which are dwarf, stout and erect, and well furnished with luxuriant leaves to the base of the flower, as compared with the long, slender and sparsely leaved growth of older kinds. And the blooms in many cases are of larger size and improved form, and better filled with florets of the best texture. Considerable progress has also been made in providing good types of the most desirable colors to bloom at the various seasons, early, medium and late. Mrs. E. G. Hill and Mrs. H. McK. Twombly, for example, are invaluable additions to our earliest varieties, as are Eugene Dailledouze and Titian to the mid-season set, and Challenge, Laredo and Mrs. J. George Ils to the late flowering sorts. Niveus, Fig. 52, in all essentials comes nearest to the American ideal of a perfect variety.

The tendency to low growth in the stems, while of much utility when blooms for cutting are the main consideration, is of far greater importance in the production of decorative and specimen plants. It is not forgotten that blooms with two or three feet of stem are a necessity in the cut flower trade, but there is probably little danger of the dwarfing of the plants being carried so far as to render the flowers they produce unmarketable or useless for cutting. Plants for decoration and exhibition can hardly be too dwarf or stocky in growth, and it is in this connection that such varieties as Golden Ball, which may be developed in excellent form with one-third of the labor and expense usually required in staking and training, will ultimately assert themselves and increase in popularity. Perhaps the one feature of chrysanthemum development which affords little or no indication of progress is the color of the flowers. It is true that a few novel shades have been produced, but these are of such indifferent character that their utility is doubtful, and most of them, from the florist's point of view, are certainly valueless. The most serviceable flowers for decorative purposes, and hence for commercial work, are those of well defined colors, and in this direction but little has been accomplished in the last few years.

During the past season we grew many of the more recent kinds, with a view to arriving at some definite conclusions in these and kindred matters. They were grown side by side in the center (solid) bed of a long-span-to-the-south greenhouse. This bed is 60 feet long by 6 feet wide, and the prepared compost, resting on a heavy clay bottom, is about 12 inches in depth, the constituents of the mixture being decomposed clay-sod and well-rotted manure, about three parts of the former to one of the latter. It was late in the season when operations were begun, the plants having been placed in position, about ten inches apart, August 9 and 10. When they had fairly started into growth, some three weeks after planting, a light mulching of short barnyard manure was applied, and twice during the season the bed was dressed with a commercial fertilizer, each time scattering about three pounds of the artificial manure over the entire surface of the bed. Manure-water, prepared from unadulterated cow-dung, was given twice a week until the buds began to show color, when all manuring practically ceased. The liquid was applied at first in very weak solution, using a three gallon measure of the solid manure to 100 gallons of water, and gradually increased in strength until the end. Water was applied as the plants appeared to need it, and after bright days they were sprayed overhead. Each plant was restricted to one stem, which was trained to a bamboo stake, and only one bud, crown or terminal was allowed to develop on each. As a result of the late planting, the flowering of the plants was generally late, and a number of them, which were rather small and weakly at the outset, failed to bloom. In the way of comparing the varieties when grown under equal conditions, however, the test was fair and carefully made.

Our notes on the leading varieties which bloomed with us are given in detail. In parenthesis following the name of the plant will be found the name of the disseminator and date of distribution. Then comes a general estimate of the variety, followed by descriptive particulars. Where we had two or more plants of a variety, one was grown to a crown bud and the other to a terminal. These terms are represented by their initials in the notes set back from the margin, which refer to the taking of the buds and their arrival at the stage of full development. The errors in names as received from the dealers were few in number, and apparently due to displacement of the labels at some time. One plant of Judge Hoitt was received from Messrs. E. G. Hill & Co., under the name of Andes; Messrs. Peter Henderson & Co. and Messrs. Pitcher & Manda supplied Yellow Hammer under the name of Condor; one plant of Mrs. E. G. Hill came from Messrs. Peter Henderson & Co. under the name of Mdme. Ed. Lefort, and Messrs. Pitcher & Manda described some other variety as Elizabeth Bisland in their catalogue of 1894.

NOTES ON SOME RECENT VARIETIES GROWN AT CORNELL. 1894.

T. *Terminal — A flower or flower-bud produced by a lateral shoot.*
C. *Crown — The solitary flower or flower-bud which is sometimes borne at the extremity of the main stem.*

Adele Merz (*Pitcher & Manda*, 1894) — Medium quality. Stem 36 inches high, strong and erect. Flower 6 inches diameter, showing center a trifle. Florets medium width; reflexed; moderately firm in texture and of rich rose color. Syn. Stanley Baxter.
Taken September 26. At best November 10.

American Eagle (*Pitcher & Manda*, 1894) — Anemone. Medium. Stem 34 inches high, rather weak. Flowers 5 to 6 inches diameter, full and perfect; largest and best to crowns. Ray florets in a single row, horizontal, medium width; white. Disk full and high; florets rosy purple.
T. Taken October 8. At best November 16.
C. Taken October 8. At best November 10.

Andes (*Pitcher & Manda*, 1893) — Excellent. Stem 27 inches high, stout and erect. Flowers 6 inches diameter, very full and strikingly decorative. Florets broad, incurved; the lower ones drooping a little and slightly curled and twisted; heavy in texture and of rich bronze-yellow color.
C. Taken October 11. At best November 29.

A. T. Ewing (*Hill & Co.*, 1893) — A very beautiful variety. Stem 26 inches high, stout and erect. Flower 6 inches diameter; full, and very regular in shape. Florets spreading; broad; heavy in substance; ground color white, margined and suffused with brilliant rose.
T. Taken October 16. At best November 14.

Beau Ideal (*Hill & Co.*, 1893) — Very good. Stem 28 inches high, moderately strong and erect, and of equal strength under

crowns and terminals. Flowers 5½ inches diameter; full, and equally good from crowns and terminals. Florets irregularly spreading; broad; good in substance and of a bright pink color.
T. Taken October 11. At best November 29.
C. Taken October 30. At best December 13.

Beauty of Exmouth (*Godfrey*, 1893) — Very good. Stem 32 inches high, and moderately strong and erect. Flowers 6 inches diameter, very full and decorative. Florets twisted and curled in all direction; medium width; firm in texture; pure white. An English seedling.
C. Taken October 8. At best November 8.

Bonnie Marjorie (*Pitcher & Manda*, 1894) — Medium. Stem 35 inches high, rather weak. Flower 4½ inches diameter, full and of good form. Florets broad; heavy in texture; incurved and of pale yellow color.
T. Taken September 26. At best November 11.

Challenge (*Hill & Co.*, 1894) — A choice variety. Stem 20 to 30 inches high, weakest and shortest under terminals, stout and erect under crowns. Flowers massive, 5 to 6 inches diameter; largest and best from crowns; very deep and full. Florets partially incurved; broad; firm of texture; light yellow in color.
T. Taken September 28. At best November 29.
C. Taken September 28. At best November 29.

Charles Davis (*Davis*, 1894) — Extra fine. Stem 27 to 35 inches high, moderately strong and erect, strongest and longest under terminals. Flowers 6 to 6½ inches diameter, very full and graceful; largest and best from terminals. Florets irregularly reflexed; broad; of medium substance and light bronze color. This is of English origin, a sport from Viviand Morel, and one of the few European varieties that do well in this country.
T. Taken September 27. At best November 1.
C. Taken September 28. At best November 6.

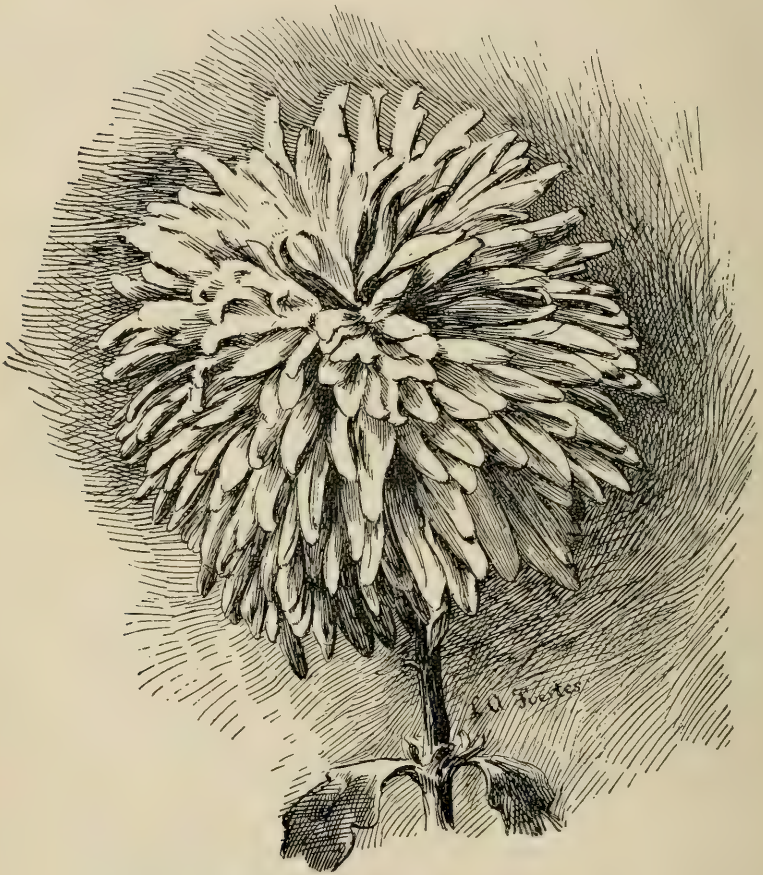
Charlotte (*Pitcher & Manda*, 1894) — Medium quality. Stem 30 to 36 inches high, strong and erect, shortest and strongest under crowns. Flower 5 inches diameter, full and of good depth. Florets regularly incurved; texture moderate; medium width; ivory-white in color.
T. Taken September 26. Flower deformed.
C. Taken September 27. At best November 13.

Clinton Chalfant (*Chalfant*, 1894) — Very good. Stem 25 to 36 inches high, moderately strong and erect, shortest and strongest under crowns. Flower 5 inches diameter, full and perfect; largest and best from crowns. Florets straight; medium width;

firm in substance; color bright yellow. A sport from Joseph A. White. Fig. 49.

T. Taken September 28. At best November 28.

C. Taken October 17. At best December 9.



49.—Clinton Chalfant. (Half Size.)

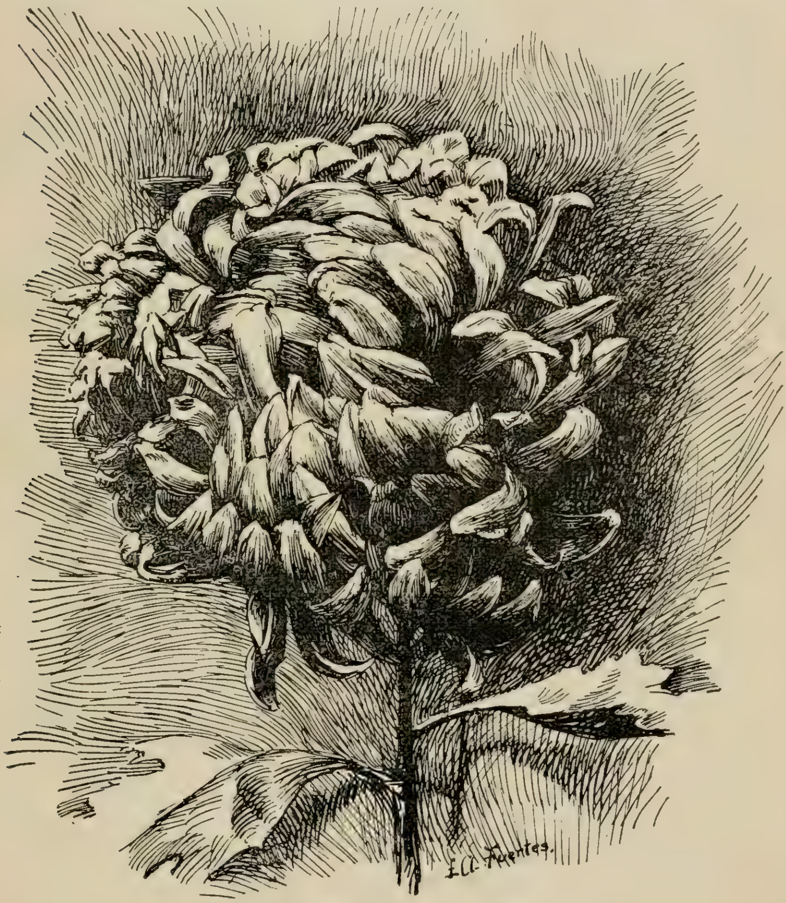
Creole (*May*, 1893) — Very good. Stem 36 inches high, strong and erect. Flower 5 inches diameter, moderately full. Florets irregularly incurved, extra wide, firm in texture, and of deep amaranth color.

T. Taken October 3. At best November 18.

Elizabeth Bisland (*Pitcher & Manda*, 1894) — A typical Japanese variety of high quality. Stem about 45 inches high, rather weak; strongest under terminals. Flower 7 to 8 inches diameter, crown buds producing those of the larger size; very full and irregular. Florets narrow; light in texture and of canary yellow color. A grand keeper.

T. Taken September 27. At best November 10.
C. Taken September 13. At best October 30.

Eugene Dailledouze (*Hill & Co.*, 1894) — Superlative. Stem 40 to 45 inches high, longest to crowns; stout and rigid. Flower 6 to 7 inches diameter, crowns larger and fuller than terminals; of great depth. Florets wide and of heavy substance; irregularly incurved; rich orange yellow. Fig. 50.



50.—Eugene Dailledouze. (Half Size.)

T. Taken October 3. At best November 10.
C. Taken October 3. At best November 21.

Garza (*Pitcher & Manda*, 1894) — Anemone. Very good. Stem 19 to 26 inches high, equally strong under crowns and ter-

minals. Flower 5 inches diameter; very perfect; best blooms from crown buds. Disk full and compact; florets white, tinged light yellow. Ray florets broad, pure white; standing out horizontally.
T. Taken September 26. At best November 9.
C. Taken October 11. At best November 22.

George R. Gause (*Hill & Co.*, 1893) — Very good. Stem 34 inches high; rather weak, though erect. Flower 6 inches diameter; very full and of great depth. Florets irregularly spreading; medium width; light of texture; reddish-bronze color.
T. Taken September 27. At best Nov. 20.

George Schlegel (*Pitcher & Manda*, 1894) — Poor quality. Stem 49 to 53 inches high: moderately strong and erect; highest and strongest under crowns. Flower 4½ to 5 inches diameter; largest and best from crowns. Florets wide; well incurved; pure white.
T. Taken September 26. At best November 12.

Georgienne Bramhall (*Pitcher & Manda*, 1894) — Very good. Stem 36 to 38 inches high; moderately strong and erect; shortest and strongest to crowns. Flower 5½ to 6 inches diameter; largest and best from crowns; full. Florets broad, irregularly incurved, thick in texture and of pale yellow color.
T. Taken September 26. At best November 15.
C. Taken October 16. At best November 19.

Gettysburgh (*Henderson & Co.*, 1893) — Medium quality. Stem 39 inches high, strong and erect. Flower 5 inches diameter, moderately full. Florets reflexed, whirled in center; medium width; firm in texture; deep crimson.
T. Taken October 8. At best November 13.

Golden Gate (*Pitcher & Manda*, 1893) — Poor quality. Stem 31 inches high, moderately strong. Flower 5 inches diameter, showing center very much. Florets broad, reflexed, and of light yellow color.
T. Taken September 27. At best November 13.

Golden Hair (*Smith & Son*, 1894) — Very good. Stem 26 inches high, stout and erect. Flower 5½ inches diameter, moderately full. Florets irregularly incurved; broad; very hairy; of heavy substance and rich golden bronze color.
T. Taken October 11. At best December 7.

Golden Wedding (*Henderson & Co.*, 1893) — One of the best. Stem 38 inches high, stout and erect. Flower 6 inches diameter; full, and very attractive in form. Florets irregularly incurved; medium width and substance; deep yellow.
T. Taken October 3. At best November 19.

Hon. Thomas Lowry (*Pitcher & Manda*, 1894) — Inferior. Stem 36 inches high, weak. Flower 5 inches diameter, full. Florets wide, of good substance; pale yellow in color, faintly suffused with rose. The disseminators class it with the hirsute sections in their catalogue of 1894, but the florets show nothing of the hairy character of this group with us.

T. Taken October 3. At best November 5.

Illuminator (*May*, 1893)—Very good. Stem 45 inches high, stout and erect. Flower 5½ inches diameter, full. Florets spreading informally; broad; medium texture; bright yellow.

T. Taken October 11. At best November 15.

Ingomar (*Smith & Son*, 1894)—Excellent. Stem 58 inches high, strong and erect. Flower 7½ inches diameter, full and graceful. Florets spreading; medium width and texture; light bronze shade.

T. Taken October 3. At best November 29.

Jessie Godfrey (*Pitcher & Manda*, 1894)—Very good. Stem 40 inches high, and of medium strength. Flower 5½ inches diameter; very full and of good depth and excellent form. Florets incurved, those in the center whirled; medium width; white, with light traces of pink.

T. Taken September 26. At best November 8.

J. J. Hill (*Pitcher & Manda*, 1894)—Medium. Stem 42 inches high, stout and rigid. Flower 5½ inches diameter, very full. Florets reflexed; medium in width and texture; rich golden-yellow.

T. Taken September 26. At best November 15.

Joey Hill (*Hill & Co.*, 1893)—One of the best. Stem 52 inches high, strong and erect. Flower 6 inches diameter, very full, and excellent in form. Florets broad, the lower ones reflexed, those in center midway between erect and reflexed; strong in texture; upper surface rich, dark velvety red, reverse old gold color.

T. Taken September 27. At best November 6.

Judge Addison Brown (*Spaulding*, 1894)—Very good. Stem 27 inches high, moderately strong and erect, of equal height and strength under crowns and terminals. Flower 4½ to 5½ inches diameter, largest and best from crowns; very full. Florets informally incurved; broad; notched at the tip; strong in substance, and of deep bronzy-yellow color.

T. Taken September 26. At best November 23.

C. Taken October 23. At best December 8.

Judge Hoitt (*Hill & Co.*, 1893)—Anemone. Good and remarkable. Stem 42 inches high, moderately strong, but rather weak-necked. Flower 5 inches diameter, full, and of curious form. Ray florets broad, and disposed in two or three rows. Disk very large and perfect, the florets almost equal to the outside series in length. The entire flower is of a delicate pink shade.

T. Taken October 8. At best November 13.

■*Catherine Richards Gordon* (*Pitcher & Manda*, 1894)—Exquisite. Stem 32 to 36 inches high, stout and erect, shortest and strongest under crown buds. Flower 5 to 6 inches diameter; very full; most perfect and largest from crowns. Florets irregularly incurved; medium width and texture; hairy; white in color, beautifully tinged with pink.
T. Taken September 26. At best October 24.
C. Taken September 27. At best October 22.

Laredo (*Smith & Son*, 1894)—Very good. Stem 29 to 34 inches high, stout and erect, of equal height and strength under crowns and terminals. Flowers 5½ to 6 inches diameter; full; smallest but most perfect from terminals, the crown buds often developing deformed, though larger blooms. Florets informally spreading, broad; firm in texture; deep pink.
T. Taken October 16. At best December 8.
C. Taken Oct. 16. At best December 1.

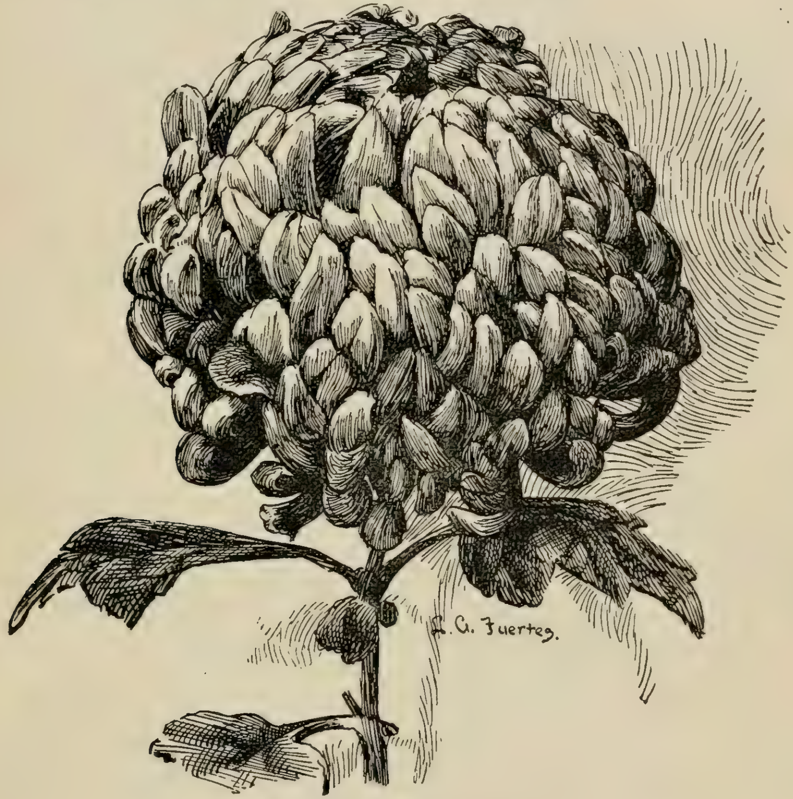
L'Enfant des deux Mondes (*Crozy*, 1893)—Very good. Stem 20 to 27 inches high, weakest and longest under terminals, moderately strong and erect under crowns. Flowers 5 inches diameter; full and of good form; best from crowns. Florets well incurved; medium width and texture; pure white and densely hairy. A sport from Louis Boehmer, introduced from Europe.
T. Taken September 27. At best November 13.
C. Taken September 28. At best November 6.

Major Bonnaffon (*Dorner & Son*, 1894)—Extra fine. Stem 27 to 29 inches high; shortest and moderately strong and erect under crowns, a trifle weak-necked under terminals. Flower 5 inches diameter; very full; faultless in form; equally good from terminals and crowns. Florets strictly and regularly incurved; broad; medium texture and of a beautifully soft yellow shade. Fig. 51.
T. Taken October 11. At best November 29.
C. Taken October 11. At best November 22.

Marie Louise (*Witterstaetter*, 1894)—One of the best. Stem 31 to 37 inches high, longest and weakest under terminals, strong and erect under crowns. Flower 6 inches diameter; full and very high in center; longest and best from crowns. Florets irregularly arranged; medium width; firm of substance; pure white.
T. Taken September 26. At best November 20.
C. Taken October 3. At best November 24.

Marion Henderson (*Henderson & Co.*, 1894)—Very good. Stem 24 to 26 inches high, strong and erect, strongest and longest under terminals. Flower 6 inches diameter; full, lasting in perfection a long time. Florets disposed in various directions; narrow, and of medium texture and canary-yellow color.
T. Taken September 27. At best November 18.
C. Taken September 28. At best November 1.

Mary Hill (*Spaulding*, 1894)—Poor quality. Stem 40 inches high, strong and erect. Flower 7 inches diameter. Florets medium width, spreading and showing center; pale pink with us; not hairy as described in disseminator's catalogue.
C. Taken October 8. At best November 12.



51.—Major Bonnaffon. (Half Size).

Maud Dean (*Hill & Co.*, 1893)—An excellent flower. Stem 28 inches high, moderately strong and erect. Flower 7 inches diameter, very full. Florets informally incurved; broad; firm in texture; deep pink color.
T. Taken September 27. At best November 21.

Mayflower (*May*, 1894)—Among the best of the season. Stem 30 to 35 inches high, strong and erect; longest to terminals. Flowers 7 to 8 inches diameter, of great depth and exceedingly full; crowns larger than terminals. Florets of medium width, curled and twisted in all directions; creamy white and of good substance.
T. Taken September 27. At best November 17.
C. Taken October 3. At best Nov. 18.

Miles A. Weeeler (*Smith & Son*, 1893) — Poor quality. Stem 32 inches high, weak-necked. Flower 4½ inches diameter, very full and of good form. Florets well incurved; broad and of heavy substance; pale yellow, tinged reddish.
T. Taken October 8. At best Nov. 23.

Miss E. H. Kingsley (*Pitcher & Manda*, 1874) — Medium quality. Stem 26 to 42 inches high, weak-necked; longest and strongest under terminals. Flowers 5 to 5½ inches diameter, rather flat: very full and compact; largest and best from crowns. Florets informally, though closely incurved; medium in width and substance and of a very light pink shade.
T. Taken September 26. At best December 5.
C. Taken October 3. At best November 22.

Miss F. Pullman (*Pitcher & Manda*, 1894) — Very good. Stem 46 inches high, stout and rigid. Flower 7 inches diameter; very full and of good depth. Florets partially incurved; medium width and of modern texture; pure white.
T. Taken October 3. At best November 1.

Miss Hattie Bailey (*Smith & Son*, 1894) —Very good. Stem 44 inches high, stout and erect. Flower 6 inches diameter; very full. Florets spreading and reflexed; broad; strong in texture and of deep bronze color.
T. Taken October 11. At best November 26.

Miss Louise Hartshorn (*Pitcher & Manda*, 1894)— Poor quality. Stem 37 to 42 inches high, weak; longest and weakest to terminals. Flower 4½ to 5 inches diameter, showing center. Florets incurved; medium width; hairy and of pink color.
T. Taken October 16. At best November 10.
C. Taken October 18. At best November 4.

Miss T. B. Harper (*Pitcher & Manda*, 1894) — Good flower. Stem 43 inches high; medium strength, holding flower erect. Flower 5 inches diameter; full. Florets incurved; narrow; pure white.
T. Taken September 26. At best November 13.

Mrs. Archibald Rogers (*Pitcher & Manda*, 1894)—Very good. Stem 40 to 50 inches high, stout and erect; longest under terminals. Flower 5½ to 6 inches diameter; very full. Florets spreading; medium width; heavy in texture and of deep rosy-purple shade.
T. Taken September 26. At best November 1.
C. Taken September 27. At best November 19.

Mrs. Charles Lanier (*Pitcher & Manda*, 1894) — Medium quality. Stem 50 inches high, and rather weak. Flower 5 inches diameter; full and of good form. Florets incurved; medium width; moderate texture and bright yellow color.
T. Taken September 26. At best November 16.

Mrs. E. G. Hill (*Hill & Co.*, 1894) — One of the best Stem 38 inches high, stout and erect. Flower 6 to 7 inches diameter; full, and attractive in form. Florets incurved; medium width; firm in texture and of bright pink color.
T. Taken September 26. At best October 24.
C. Taken September 28. At best October 20.

Mrs. F. Gordon Dexter (*Pitcher & Manda*, 1894) — Japanese Anemone. An excellent variety. Stem 36 to 42 inches high; moderately strong and longest to terminals. Flower 5½ to 7 inches diameter; full and perfect; best to terminals. Florets pale rose, 1½ inch long. Ray florets 3 to 4 inches long, drooping about the stem; color white. (See page 235.)
T. Taken September 26. At best November 6.
C. Taken October 16. At best November 30.

Mrs. George J. Magee (*Pitcher & Manda*, 1894) —Excellent. Stem 30 to 40 inches high, stout and rigid, highest under terminals. Flower 6 inches diameter; best from terminals; crowns weak, necked, showing center. Florets well incurved, wide, forming a globular flower of great depth and solidity; heavy in texture; outer surface pale pink, interior a shade darker. Keeps well.
T. Taken September 26. At best November 1.
C. Taken September 27. At best November 6.

Mrs. George M. Pullman (*Pitcher & Manda*) —Highly decorative. Stem 42 to 46 inches high, stout and erect; shortest under crowns, rather weak-necked to terminals. Flower 6 inches diameter, 9 inches when florets are held out horizontally. Florets reflexed; very long, drooping about the stem, and showing center of flower; wide; firm in texture and of deep yellow color.
T. Taken September 27. At best November 9.
C. Taken October 3. At best November 25.

Mrs. H. McK. Twombly (*Pitcher & Manda*, 1894) — Very good. Stem 27 to 30 inches high, somewhat weak under terminals, but strong and erect to crowns. Flower 5 to 6 inches diameter, full; terminals largest and best. Florets incurved; broad; firm in texture; white, delicately shaded pink.
T. Taken September 26. At best November 10.
C. Taken September 28. At best November 1.

Mrs. Howard Rinek (*Pitcher & Manda*, 1894) — Very good. Stems 44 inches high; strong but weak necked. Flower 5½ inches diameter; very full, and of perfect globular form. Florets well incurved; wide; strong in texture and somewhat hairy; deep pink on inner surface, silvery pink externally.
T. Taken September 26. At best October 16.

Mrs. James B. Crane (*Pitcher & Manda*, 1894) — Medium quality. Stem 42 inches high, strong and erect; equally good under crowns and terminals. Flower 5 to 6 inches diameter, mod-

erately full; largest and best from crowns. Florets irregularly incurved; wide; strong in substance and of deep rose color.
T. Taken September 26. At best November 13.
C. Taken September 27. At best November 9.

Mrs. J. George Ils (*Sievers*, 1894) — A grand variety. Stems 50 to 60 inches high; strong, but owing to the great weight of the flower, not erect; longest and strongest to terminals. Flower 7 to 8 inches diameter, very full; largest and best from terminals. Florets irregularly incurved; broad; very heavy in texture; pure white.
T. Taken October 11. At best December 4.
C. Taken October 8. At best December 7.

Mrs. Marshall Crane (*Pitcher & Manda*, 1894) — Very good. Stem 46 inches high, medium strength. Flower 6 inches diameter, full and of good form. Florets incurved; medium width; strong in substance; creamy white.
T. Taken September 26. At best November 11.

Mrs. Mary A. Forepaugh (*Pitcher & Manda*, 1894) — Very good. Stem 37 inches high, moderately strong and erect. Flower 6 inches diameter, very full and of good shape. Florets regularly incurved; broad; medium texture; delicate pink, tipped yellow.
T. Taken September 26. At best December 5.

Mrs. Sarah Rose (*Pitcher & Manda*, 1894) — Very good. Stem 43 to 46 inches high, strong and erect to crowns, weak-necked under terminals. Flowers 6 to 6 inches diameter, full and perfect; largest and best from crowns. Florets slightly reflexed; narrow; medium width; pale rose.
T. Taken September 26. At best November 16.
C. Taken September 27. At best November 19.

Mrs. W. H. Trotter (*Spaulding*, 1894) — Very good. Stem 30 to 36 inches high, strong and erect; strongest and longest under crowns. Flower 5 to 5½ inches diameter, very full and high; largest and best from crowns. Florets spreading; medium width and substance; curiously laciniated at the tip; pure white. The flowers of this variety develop very slowly, and on this account they are often deformed in the center. Flowers from terminal buds are most subject to this weakness.
T. Taken September 27. At best December 6.
C. Taken September 28. At best Dec. 5.

Mrs. W. K. Vanderbilt (*Pitcher & Manda*, 1894) — Very good. Stem 40 inches high, moderately strong and erect. Flower 5½ inches diameter, quite full. Florets spreading; medium width and texture; pure white.
T. Taken September 26. At best November 22.

Mrs. Wm. Trelease (*Pitcher & Manda*, 1893) — Excellent. Stem 42 inches high, moderately strong and erect. Flower 7 inches diameter, very full and of good form. Florets reflexed; medium width; slightly hairy and of deep pink shade.

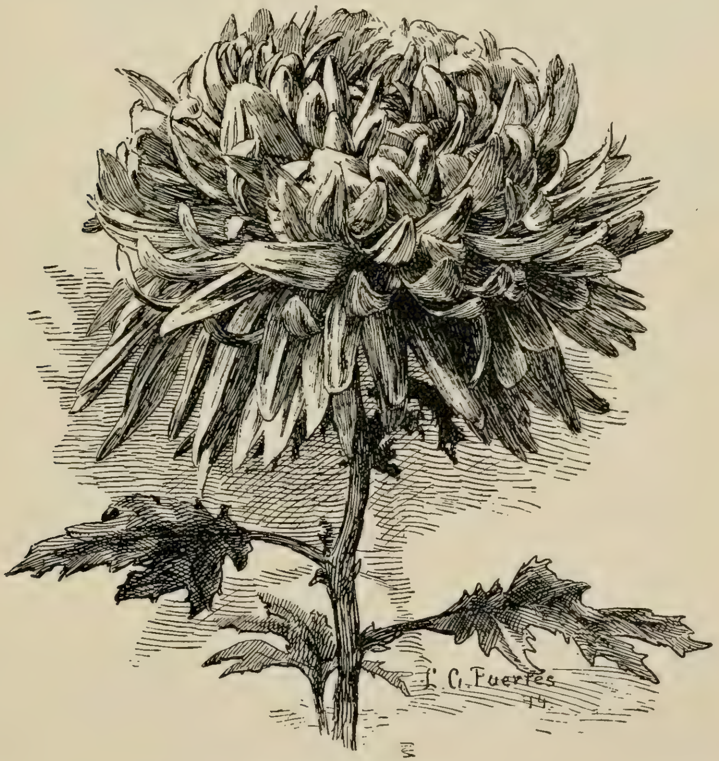
T. Taken September 27. At best November 20.

Mrs. W. R. Merriam (*Pitcher & Manda*, 1894) — Very fine. Stem 38 inches high, strong and erect. Flower 7½ inches diameter and of good form. Florets wide and of good substance, the inner ones incurved, those around the outside straight or slightly reflexed. This is by no means a reflexed flower, as the raisers have classed it.

T. Taken September 26. At best November 1.

Mutual Friend (*Mann Bros.*, 1894) — An excellent sort. Stem 19 to 24 inches high, moderately strong and rigid; weakest and longest under terminals. Flowers 5 to 6 inches in diameter, terminals larger and fuller than crowns. Florets reflexed, irregular; wide; medium substance; pure white.

T. Taken September 25. At best November 8.
C. Taken September 25. At best November 5.



52.—Niveus. (Half-Size.)

Niveus (*Smith & Son*, 1893) — One of the best. Stem 36 to 40 inches high, stout and erect. Flower 6 inches in diameter, very full; perfect in form. Florets incurved in center, slightly reflexed around edge; extra wide; strong in texture; pure white. See Fig. 52.

C. Taken October 11. At best November 16.

Pitcher & Manda (*Pitcher & Manad*, 1894) — Very good. Stem 26 to 36 inches high, moderately strong and erect; strongest and shortest under crowns. Flower 5 to 6 inches diameter, very flat and full; largest and best from crowns. Florets straight and stiff; medium width; the outer ones white, tinged pink; those in the center yellowish.

T. Taken September 26. At best November 9.
C. Taken September 28. At best November 20.

President W. R. Smith (*Hill & Co.* 1893) — Medium quality. Stem 30 to 36 inches high, strong and erect. Flower 5 inches diameter; moderately full; equally good from crowns and terminals. Florets straight and spreading; medium width and substance; pale pink color.

T. Taken October 3. At best November 8.
C. Taken October 3. At best November 13.

R. L. Beckert (*Spaulding* 1894) — Very good. Stem 30 to 34 inches high, moderately strong and erect. Flower 5½ to 6 inches diameter; full. Florets loosely incurved, the center series straight; medium width; strong in texture; deep bronze yellow.

C. Taken October 11. At best November 20.

Robert M. Grey (*Pitcher & Manda*, 1894) — Poor quality. Stem 46 to 48 inches high, moderately strong and erect; strongest and shortest under crowns. Flower 5 to 6 inches diameter. Florets incurved, showing center very much; medium width and texture; densely hairy, and of an odd though showy reddish tinge.

T. Taken October 11. At best November 13.
C. Taken October 11. At best November 8.

Sayonara (*Chandler*, 1894) — Medium quality. Stem 38 inches high, rather weak. Flower 6 inches diameter; full, and of good keeping character. Florets spreading, the lower ones drooping about the stem; medium texture; pale sulphur-yellow color.

T. Taken September 28. At best November 10.

Silver Bill (*Pitcher & Manda*, 1894) — Anemone. Medium quality. Stem 23-26 inches high, rather weak; strongest and shortest under terminals. Flower 3½ to 4 inches diameter, and fairly perfect; largest and best from crowns. Ray florets horizontal, arranged in several rows; narrow; pure white. Disk full and of good form; florets white, tipped yellow.

T. Taken September 26. At best November 5.
C. Taken September 27. At best November 11.

Thomas Emerson (*Pitcher & Manda*, 1894)—Fairly good. Stem 28 inches high, strong and erect. Flower 6 inches diameter; somewhat loose. Florets incurved; broad; medium substance; bright yellow.

C. Taken September 26. At best November 6.

Titian (*May*, 1894)—A superlative variety. Stem 36 inches high, stout and erect. Flower 7 inches diameter; very full and o great depth and fine form. Florets broad; reflexed; firm in texture and of a deep rosy pink shade.

C. Taken October 8. At best November 17.

Toucan (*Pitcher & Manda*, 1894)—Anemone. Poor quality with us. Stem 30 inches high, moderately firm. Flower 3½ inches diameter, poor in form and color. Disk florets yellowish; rays pale red.

C. Taken October 2. At best November 23.

Wanlass (*Spaulding*, 1894)—Very good. Stem 50 inches high, strong and erect. Flower 5 inches diameter, very full. Florets informally incurved; medium width; solid substance, silvery pink in color, the interior florets tipped yellow.

T. Taken October 11. At best December 6.

W. C. Cook (*Pitcher & Manda*, 1894)—Medium quality. Stem 48 inches high, rather weak. Flower 5½ inches diameter, moderately full and compact. Florets incurved; wide; good in texture; color deep yellow. Syn. Chas. A. Jessup.

T. Taken October 26. At best November 13.

W. G. Newitt (*Hill & Co.*, 1893)—Very good. Stem 30 inches high, stout and erect. Flower 5 inches diameter, very full. Florets somewhat irregularly disposed, the outer ones reflexed, those in the center erect or slightly incurved; texture medium; pure white.

T. Taken October 11. At best November 12.

William Seward (*Seward*, 1892)—Very good. Stem 23 inches high, stout and erect. Flower 6 inches diameter, very full. Florets loosely spreading; medium width and texture; dark crimson. European.

C. Taken October 8. At best November 9.

Yellow Hammer (*Pitcher & Manda*, 1894)—Excellent. Stem 33 inches high; a trifle weak; strongest under crowns. Flower 4 to 5 inches diameter; crowns largest and best. Ray florets of medium width, arranged in single horizontal row; bright yellow. Disk very full and perfect; florets of a deeper yellow shade than rays.

T. Taken October 3. At best November 25.

C. Taken October 10. At best November 23.

METHODS OF CULTIVATION.

Many systems of cultivation are employed, and as each method has its special advantages, that to be adopted must be decided by the individual grower according to his circumstances. The plants are propagated during the spring months, grown in pots for a time, and finally placed in benches or borders under glass. They may also be grown in pots throughout the year, or planted in the open ground for the summer months and transferred to pots early in autumn. The best results are undoubtedly obtainable under pot culture, as witness the marvellous plants and blooms produced by this process in England; and the best plants we have so far seen in this country have been grown in pots. The reason of this is not difficult to trace. The roots of plants in pots are confined to certain limits and beneficial food, and a grower of ordinary experience may readily supply any nourishment which, from the behavior of the plant, appears to be lacking, or withhold any injurious application of water or stimulants. This cannot be accomplished successfully by any other mode of culture. But except in those rare instances where fully developed specimens are desired for exhibition purposes, exclusive pot culture is not advisable in this country. The heat and drought of our summers render it too expensive.

Where marketable or exhibition blooms are required, beds or benches under glass afford the most economical means of growing these plants. There is, as has been lately evidenced in the horticultural press, some disparity of opinion as to the relative merits of beds and benches. It should be understood that the term bed here applies to a solid mass of earth the sides of which may be defined by boards or masonry, but the body of soil of indefinite thickness, with from six to eight inches of prepared compost on the top. A bench, on the other hand, has bottom and sides restricted, with capacity for a body of soil averaging six inches in depth. Our experience has amply demonstrated that the benches, under proper treatment, give the best results. The condition of the soil, as to moisture and fertility, can be better controlled in the latter; and in this regard bench culture comes nearer the perfection of pot treatment than any other system. One great difference presents itself in that the plants, with roots spreading at will throughout the soil, must be treated collectively rather than individually. This is a drawback of no mean importance where numerous varieties are planted indiscriminately in the same bench, but one which may be eliminated to an appreciable degree by growing the plants of each variety in partially isolated batches, or, as is the common practice in large commercial establishments, by devoting an entire bench to a single variety.

Although hardly so satisfactory as benches, beds have some advantages. A point largely in their favor is their still greater economy. The material and work of a bottom are saved, and this becomes a very important item when the receipts and expenditures are compared. There is a further saving in labor, for the watering of plants in beds does not require such persisted attention as that of those in pots or benches. An experienced grower, by the exercise of good judgment in watering, may often secure blooms in beds fully equal in quality to the best raised on benches.

With regard to the financial side of chysanthemum growing it must be said that there are at least ten purchasers of moderate priced flowers of medium quality to every one who will demand blooms of faultless character and pay the highest price for them. The writer has an impression that the proportion in favor of the inferior flowers is on the whole much greater than this, although the assurances given him by retail dealers of long standing in eastern cities do not exceed the degree stated. Some will be inclined to say on the strength of this reasoning that it would not be profitable to grow flowers of the best quality. This would be an erroneous impression, tending to defeat the purpose of these remarks, which is to encourage the best rather than excuse questionable methods, and yet to assure those of inferior opportunity that their position is by no means hopeless. The number of growers who produce lower grade flowers is far in excess of those who can rise to the greater requirements of their profession, and so far there is no reason to believe that the supply of greenhouse products of high quality is greater than the general demand. Poor flowers do not sell to advantage, but there are many profitable grades between the poor and the best. Perhaps the lowest grade of marketable flowers are those obtained from plants grown out of doors during the summer months. These plants are taken up in August and placed in pots or boxes. During the latter part of September, when the nights become chilly, they are removed to a sunny greenhouse, where in due time they bloom profusely. The flowers of such plants, in their natural clusters, are much esteemed by many purchasers; and if the plants themselves have had some little staking and training after potting, they can be sold readily.

INSECTS FRIENDS AND ENEMIES.

The insects most commonly found on chrysanthemums are here named and some descriptions of them and their work, with instructions for the eradication of detrimental kinds, are given to enable the inexperienced to deal with all according to their deserts.

Ants.— The little brown ants so common in greenhouses and on plants grown therein are not injurious. Occasionally they appear in such large numbers that their presence is objectionable; but it should be remembered that they are great scavengers, and while working little or no injury to the plants, they clear them of a lot of objectionable matter in the form of dead and dying insects. Their presence should therefore be tolerated.

Black Aphis.— Entomologists are undecided about the specific position of the much dreaded black aphis of the chrysanthemum, although it is apparently one of the commonest of the plant lice of greenhouses. It multiplies with amazing rapidity, and is found on the young shoots and leaves of many cultivated plants, being very partial to chrysanthemums, deforming the foliage and destroying its vitality. It is easily held in check by the frequent application of pyrethrum powder, or by fumigation with tobacco.

Caterpillars.— The green caterpillars which abound on chrysanmums indoors and out, all through the growing season, are very destructive. They live upon the fleshy portion of the leaves, leaving only the thin epidermal covering of the upper surface, and occasionally devouring the leaves bodily. Sometimes they also attack the soft young shoots, treating them in similar fashion. They are easily traced by their work and their blackish excrement, and they should be at once picked off and destroyed. Usually they are found on the under side of the leaves.

Chrysopa.— We have a friend in the larvæ of the lace wing fly, of the group of insects known to entomologists under the name of Chrysopa, which is an insatiable enemy of aphids and kindred pests. This larva is of greyish color, and nearly an inch in length. It kills and devours the minor insects in large numbers, and in this respect is certainly one of the best helpers of plant growers. The perfect insect is extremely pretty, having beautiful green lace-like, wings and golden eyes.

Green Fly.— Perhaps the most familiar of all greenhouse insects is the aphis commonly known as the green fly. The young and tender branches of soft-wooded plants are its favorite abode, and where once it gets a footing, it speedily becomes plentiful. The insects feed upon the juices of the plant, which soon shows the result in its sickly appearance and ultimate death. The insects and their deposits also render the foliage and flowers very unsightly even before they have effected any serious injury. Tobacco smoke is the best remedy.

Lady Birds are common everywhere during the summer months, and they sometimes make their appearance in greenhouses in winter and spring. They and their larvæ feed largely on the various aphids, and in this way do valuable work while they cause no injury to the plants. Sometimes they are very common, and appear to pervade every nook and corner, and at other times it is difficult to find a single specimen. They should never be destroyed.

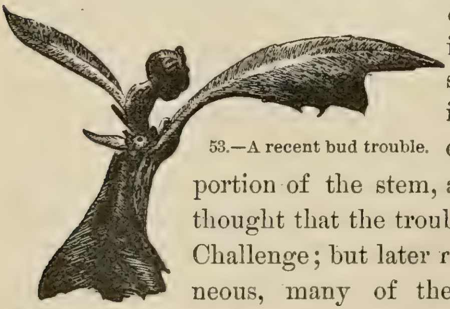
Mites.—Much havoc was made among verbenas some years ago by insects commonly known as mites. This is the two spotted mite, *Tetranychus bimaculatus*, a close relative of the red spider. It appears to be common now in the greenhouses of many parts of the country, attacking plants of various kinds, chrysanthemums among the number. It is a small whitish insect, more inconspicuous than the red spider, and affects the plants in much the same way. It is extremely difficult of eradication, and thrives best in a dry atmosphere. If the house and plants are kept constantly damp, the mite does less damage. It can also be despatched with kerosene emulsion. The emulsion should be diluted—twenty-five to thirty parts of water to one of the emulsion—and applied often, say three or four times or even more a month. Two applications made in quick succession will probably annihilate all the fully developed insects on the plants, but the numerous eggs are probably still unaffected, and in the course of a week or two the plants are as bad as ever. A dilute mixture is preferable to a strong one for the reason that it spreads more readily over every part of the plant, and some care should be taken to wet the entire plant. The mites are generally most numerous on the lower side of the leaves, and particular pains should be taken in applying the material to these parts. It is generally supposed that the peculiar "frozen" appearance of Golden Wedding and other varieties is due to the ravages of these insects, but this is a mistake. The trouble with those varieties is of an altogether different nature, and one that is said to be caused by a fungus, which may be exterminated by a liberal use of Bordeaux mixture.

Red Spider.—Like the preceding, the red spider, *Tetranychus telarius* of scientists, is so small that it has often done serious injury before it is noticed. In a dry atmosphere it forms a regular maze of web-work on the under side of the leaves of the plants, and, if unchecked, in time extends over every part of the entire collection. The treatment is to keep the plants and houses damp.

Tarnished Plant Bug (*Lygus pratensis*).—Among chrysanthemum growers this pest is perhaps better known as the chrysanthemum fly. This insect is very common, and we are indebted to it for the injury known as "blind growths" or "blind buds." It is of stout build, about one-fourth of an inch in length, and of brownish or yellowish color. It attacks a great variety of plants, both ornamentals and fruit plants, and seems especially fond of chrysanthemums. Anyone who has collected seeds of our hardy herbaceous perennials in autumn must have come in contact with it, for it abounds in the flower heads of asters, solidagos and the like. It punctures the young growths, buds and leaves of chrysanthemums, extracting and subsisting on their juices, and thus renders them useless. Pyrethrum powder and kerosene emulsion are the best preparations for destroying the pest, but where the insects are few in number they may be collected by hand with little trouble.

Thrips.—Several species of these little insects infest garden plants. It is known that they injure the foliage by mutilation and by withdrawing its fluids, and their black deposits have the effect of putting a decided stop to the development of the leaves. When the dark, roundish spots are noticed, both surfaces of the leaves of plants out of doors should be thoroughly sprayed with tobacco water, and plants in similar circumstances under glass should be fumigated with tobacco.

A Recent Bud Trouble.—A new source of annoyance has appeared within the past year in the form of the premature death of the flower buds. The stem immediately beneath the bud swells to some extent, and this is followed by the gradual decay of the bud and a small portion of the stem, as in Fig. 53. At first it was thought that the trouble was confined to the variety Challenge; but later reports prove this to be erroneous, many of the prominent varieties being affected in the same way, and we have had the variety Red Robin



53.—A recent bud trouble.

attacked while Challenge grown in the same house remained unharmed. It has been said that mites are the cause of the malady, and again it is attributed to a fungus, while others look for a bacterial origin. It is more probably due to external mechanical injury caused by some insect much larger than the mites, or in disbudding. In any case it would be well to take the precaution of allowing the buds to attain to good dimensions previous to disbudding.

SUMMARY.

Popular interest in chrysanthemums in America dates from the distribution and extensive advertising of the variety Mrs. Alpheus Hardy in 1888–89.

Varieties for commercial purposes should have dwarf stems (from three to four feet high), strong and erect, furnished with luxuriant foliage to the base of the flowers, which should be large (from four to eight inches in diameter), double, and of a distinct shade of color.

For the purpose of American growers, the American varieties are in general far superior to those of foreign origin.

New varieties should be submitted to the Crysanthemum Society of America, or its representatives, before being placed on the market. Growers should support the society in its efforts to prevent the increase of synomyms.

Among the new varieties of last year the best for commercial purposes at our place were Eugene Dailledouze and Major Bonnaffon, yellow; Mayflower and Marie Louise, white; Mrs. E. G. Hill and Laredo, pink; and Charles Davis and Ingomar, bronze.

The best flowers are obtained by bench culture, although good marketable blooms are more cheaply raised on solid beds.

Some study should be given to the insects which infest the plants, so that the helpful ones may be readily distinguished from those of injurious character. The leading injurious ones are black aphis, green fly, mites and thrips.

The plants are kept free from insect pests by using either pryethrum powder, kerosene emulsion or tobacco, the last to be applied in the powder form or in frequent light fumigation.

As the premature decay of the flower buds is probably due to external injury, greater care should be exercised in disbudding, allowing the buds to attain to a good size before commencing the operation.

MICHAEL BARKER.

THE TESTING OF VARIETIES.

In answer to inquiries respecting our attitude towards the testing of varieties, I append the following statements of the methods which the Horticultural Division of the Cornell Experiment Station has uniformly pursued. We refuse to test varieties simply because they are new. Our basis of study is the monograph — the investigation of a particular subject, rather than the indiscriminate growing of things which chance to be put upon the market in a given year, and which have no relationship to each other aside from a coincidence in date. When we take up a certain group of plants for study, we endeavor to secure every variety of it, old or new. These varieties are studied not only in the field, but botanical specimens are invariably made of every one, so that the experimenter has specimens before him for leisurely study when the hurry of field work and the excitement of bug catching are done. We are always glad to receive the seed novelties of any year, but we do not agree to report upon them or even to grow them. If we were to attempt to grow them all, we should simply be making a museum of curiosities, and we would have no time left for investigation and experiment. More than this, we have to admit that we are incompetent to make a test of all novelties. An opinion of a novelty is of no value unless the person who gives it is well acquainted with all, or at least most, of the other varieties of the plant, and we find it impossible to know all garden plants. There are many kinds of fruits and vegetables with which we have only a passing acquaintance, and it would be presumptuous for us to affect a critical knowledge of any variety of them, simply because it happened to be introduced in any given year.

Seedsmen and others, therefore, must not expect reports upon the novelties which they send us, unless the varieties happen to be of plants to which we are giving explicit study. Roots and trees which are sent us are always planted as a part of our collection, and they are given the same attention as other parts of our plantation ; but we do not agree to test them for publication, although we are always glad to make a written statement of their behavior.

L. H. BAILEY.

BULLETIN 92—May, 1895.

Cornell University—Agricultural Experiment Station.
AGRICULTURAL DIVISION.

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ON THE EFFECT OF

FEEDING FAT TO COWS

By Henry H. Wing.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in Western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. On the Effect of Feeding Fat to Cows.

On the Effect of Feeding Fat to Cows.

It is the common opinion of dairymen that the food exerts a great influence upon the quality of the milk, although experiments have long since shown that, in most cases, the quality of the milk is dependent upon the individuality of the cow and is very little affected by the food. The first experiments leading to these conclusions were made in Germany, but several of the American Experiment Stations have experimented along the same lines and in general have confirmed the results of the foreign experimenters.

These experiments, for the most part, have been made to show the influence of rations relatively rich or poor in nitrogen upon the quality of the milk. Comparatively few experiments have been made to show the influence of rations relatively rich or poor in fat upon the milk. This is no doubt due to the fact that it has long been conceded that the nitrogenous part of the ration is the source of a large part, if not all, of the fat in the milk. There have, however, been some experiments made upon feeding foods rich in fat. The most important of those made in this country were made by Wood of the New Hampshire Agricultural Experiment Station,* in which cotton-seed oil, palm oil, cocoanut oil, oleo oil and stearin were added to a ration composed of hay and ensilage and a grain ration of eight pounds of equal parts of ground oats and middlings. The oils were fed in turn to three different cows in periods of two weeks each. Daily analyses of the milk were made and the conclusions arrived at were as follows:

"That the first effect of an increase of fat in the cow's ration was to increase the per cent. of fat in the milk.

"That with the continuance of such a ration, the tendency was for the milk to return to its normal condition.

"That the increase in fat is not due to the oils, but to the unnatural character of the ration.

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* New Hampshire Experimental Station, Bulletin No. 20.

"That the results of feeding oils tend to confirm the conclusions that the composition of a cow's milk is determined by the individuality of the cow, and that although an unusual food may disturb for a time the composition of the milk, its effect is not continuous."

Juretschke has found* as a result of the addition of four to five pounds per thousand pounds live weight, of cotton seed cake, rape cake, and peanut cake to a basal ration consisting of hay, straw, brewers' grains and wheat bran, that the "milk secretion is not directly, but only indirectly, affected by the feeding, and that the feeding of large amounts of fat does not increase the amount of butter fat in the milk."

Spier† concludes as follows, as the result of feeding cows on pasturage, brewers' grains and potatoes with bean meal, cotton-seed cake, barley meal and linseed cake, that "although the quantity of milk is easily influenced up to a certain point by the food supply, the quality is not materially altered by any ordinary mixed food.

"The proportion of butter fat is very little influenced by foods containing a large percentage of oil, such as linseed or cotton cake, nor yet by albuminous food, such as bean or pea meal, decorticated cotton cake, etc."

On the other hand, some experiments made by Mr. Henry Van Dreser, of Cobleskill, N. Y., and reported in Hoard's Dairyman, Vol. XXV, No. 18, p. 288, June 22, 1894, have shown a remarkable increase in the yield of fat by the addition of tallow to the ordinary ration.

In brief, Mr. Van Dreser's methods and results were as follows:

The cows, thoroughbred Holsteins, had been receiving a ration of thirty pounds of ensilage per day with hay at noon, with a grain ration of six pounds of a mixture of two parts of wheat bran, and one part each of cotton-seed meal and corn meal. The skim milk was also fed back to the cows. At the beginning, one-quarter of a pound per cow per day of clean beef tallow was shaved up and mixed with the grain ration. The cows ate the tallow readily, and in the course of two weeks the amount was increased to two pounds per day. At the end of five weeks, a week's butter test was made of each cow, the results being as follows:

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* Molkerei Seitung, Vol. VII, 38, p. 518.

† Transactions of Highland and Agricultural Society of Scotland, 1894, p. 83

NUMBER OF COW.	Weight.	Butter in one week before feeding tallow.	Butter in one week after feeding tallow.	Gain per cent. by feeding tallow.
		Lbs.	Lbs.	
1	1,189	14.00	20.00	43
2	1,130	12.00	17.05	46
3	1,168	8.50	16.875	98
4	1,000	13.06	17.06	30

The result of this experiment was so striking and so contrary to the results of similar experiments made previously that it seemed to be worth while to carry the investigation a little further.

On September 14, 1894, five cows of different ages and at different periods of lactation were selected from the University herd for an experiment in feeding tallow. The cows were as follows :

Emma, 15/16 Holstein, 4 years old, in milk 4 months and 10 days.

Freddie, 3/4 Holstein, 9 years old, in milk 15 days.

Garnet Valentine, 73,783 A. J. C. C. H. R., 3 years old, in milk 15 days.

Pearl, 7/8 Holstein, 6 years old, in milk 25 days.

Pet, 7/8 Holstein, 9 years old, in milk 5 months.

The cows were at pasture and were receiving a grain ration of 8 pounds per day of an equal mixture of wheat bran and cotton-seed meal. This, they continued to receive. During the first week from September 14th to 21st no change was made in the ration. The fat was determined in each milking separately by the Babcock test. At the conclusion of the first week 4 ounces of tallow per day were added to the grain ration night and morning. The cows ate the tallow readily and as fast as seemed best the amount of tallow was increased, four ounces at a time, until all of the cows were eating two pounds each per day. This occurred during the fourth week with all of the cows except Pet who seemed to be less fond of the tallow than the others, and did not eat the full ration until the fifth week. The experiment was then continued until the end of the tenth week, when the tallow was discontinued and the milk weighed and fat determinations made for two weeks longer.

For the first six weeks after beginning to feed the tallow, separate determinations of the fat were made for each cow for each milking. From the seventh week on, samples were taken from each

TABLE I — LOT I.

Grain Food and Tallow Consumed.

WEEK.	EMMA.				FREDDIE.				GARNET VALENTINE.				PEARL.				PET.			
	Grain.	Tallow.	Tallow per day.		Grain.	Tallow	Tallow per day.		Grain.	Tallow.	Tallow per day.		Grain.	Tallow.	Tallow per day.		Grain.	Tallow.	Tallow per day.	
	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.
Before, Sept. 14 to 21	56	....	...	...	56	....	...	...	56	....	...	...	56	....	...	...	56	....	...	...
1st, Sept. 21 to 28	56	48	..	$6\frac{6}{7}$	48	42	..	6	56	48	..	$6\frac{6}{7}$	56	48	..	$6\frac{6}{7}$	48	24	..	$3\frac{3}{7}$
2d, Sept. 28 to Oct. 5	56	94	..	$13\frac{3}{7}$	56	94	..	$13\frac{3}{7}$	56	94	..	$13\frac{3}{7}$	56	94	..	$13\frac{3}{7}$	52	64	..	$9\frac{1}{7}$
3d, Oct. 5 to 12	56	138	1	$3\frac{5}{7}$	56	138	1	$3\frac{5}{7}$	56	138	1	$3\frac{5}{7}$	56	138	1	$3\frac{5}{7}$	52	104	..	$14\frac{6}{7}$
4th, Oct. 12 to 19	56	204	1	$13\frac{1}{7}$	56	204	1	$13\frac{1}{7}$	52	190	1	$11\frac{1}{7}$	56	204	1	$13\frac{1}{7}$	52	144	1	$4\frac{4}{7}$
5th, Oct. 19 to 26	56	224	2	..	56	224	2	..	52	208	1	$13\frac{5}{7}$	56	224	2	..	51	200	1	$11\frac{4}{7}$
6th, Oct. 26 to Nov. 2	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..
7th, Nov. 2 to 9	56	224	2	..	56	224	2	..	52	208	1	$13\frac{5}{7}$	56	224	2	..	56	224	2	..
8th, Nov. 9 to 16	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..
9th, Nov. 16 to 23	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..
10th, Nov. 23 to 30	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..
After, 1st, Nov. 30 to Dec. 7	56	....	...	...	56	....	...	...	56	....	...	...	56	....	...	...	56	....	...	...
After, 2d, Dec. 7 to 14	56	....	...	...	56	....	...	...	56	....	...	...	56	....	...	...	56	....	...	...

milking for each cow separately, and a composite test of the same made each week. In the table above is shown the amount of grain and tallow consumed each week by each cow.

It will be seen that the tallow was regularly consumed in full amount by nearly all of the cows. The only exceptions were that Garnet Valentine refused one feed in the fifth week and one in the seventh week.

As the season advanced and the pastures began to fail the cows were fed dry corn stalks, and on November 6th, during the seventh week, they began to be fed corn ensilage of good quality, carrying a fair crop of ears, and mixed clover and timothy hay. This date really began the period of winter feeding.

No visible effect was noticeable in the health of the cows at any time during the experiment from the effect of feeding tallow, and weights made on November 1st and December 3d showed that the cows had practically neither gained nor lost in weight. The yield in milk and fat is shown in Table II.

It will be seen that in general there was no effect in either the yield of milk or percentage of fat that could be traced to the feeding of the tallow. During the first two or three weeks the percentage of fat rose slightly with several of the animals, notably Garnet Valentine and Pet, but toward the close of the experiment the percentage of fat fell slightly with some of the animals, notably Emma and Freddie. There was a constant downward tendency in the yield of milk with all the animals, due undoubtedly to the advancing season and the change from pasture to winter feed.

After the experiment had continued for three or four weeks and it was seen that no very marked changes in the quality of the milk were taking place it was decided to select another lot of cows for further experiment. There were in the herd several two-year-old heifers that had recently calved. They were quite thin in flesh and giving small amounts of milk of not very good quality. Several of these heifers were selected for the second lot, the idea being that perhaps they would be more susceptible to radical changes in the food. The second lot of five was selected on October 19th, consisting of the following:

Clara, grade Jersey, 2 years, 9 months old, in milk ten days.

Dora, $\frac{15}{16}$ Holstein, 3 years and 2 months old, in milk 1 month and 20 days.

TABLE II — LOT I.

Yield of Milk and Fat (by weeks).

WEEK.	EMMA.			FREDDIE.			GARNET VALENTINE.			PEARL.			PET.		
	Yield of milk. Lbs.	Average per cent. fat.	Yield of fat. Lbs.	Yield of milk. Lbs.	Average per cent. fat.	Yield of fat. Lbs.	Yield of milk. Lbs.	Average per cent. fat.	Yield of fat. Lbs.	Yield of milk. Lbs.	Average per cent. fat.	Yield of fat. Lbs.	Yield of milk. Lbs.	Average per cent. fat.	Yield of fat. Lbs.
Before	212.00	3.49	7.398	330.5	3.52	11.629	181.5	4.41	8.008	256.00	3.11	7.953	251.25	3.63	9.110
1st	204.75	3.40	6.970	342.25	3.46	11.838	191.25	4.72	9.018	251.00	3.16	7.939	257.75	3.48	8.982
2d	196.25	3.65	7.158	346.5	3.47	12.037	183.75	4.77	8.759	247.75	3.29	8.161	265.25	3.66	9.717
3d	186.75	3.27	6.116	323.00	3.6	11.633	172.25	4.85	8.351	223.5	3.51	7.842	239.75	3.86	9.266
4th	190.00	3.45	6.551	306.25	3.65	11.172	165.25	5.02	8.300	251.75	3.59	9.042	249.25	4.11	10.248
5th	176.5	2.87	5.059	323.5	3.24	10.483	152.25	4.77	7.258	256.00	3.29	8.428	232.5	3.73	8.676
6th	179.25	2.95	5.301	298.75	3.55	10.560	148.5	4.85	7.206	217.5	3.35	7.305	203.25	4.05	8 188
7th	174.5	2.95	5.148	303.00	3.35	10.151	141.75	5.00	7.088	214.5	3.25	6.971	161.5	4.00	6.460
8th	163.5	2.5	4.088	309.00	3.00	9.270	164.00	4.7	7.708	235.25	3.15	7.410	196.75	3.5	6.886
9th	152.75	3.00	4.583	290.5	3.3	9.587	158.00	4.55	7.189	229.5	3.25	7.459	207.25	3.85	7.979
10th	146.25	2.75	4.022	257.25	2.95	7.589	138.5	4.5	6.233	221.00	3.25	7.183	174.5	3.6	6.282
After 1st	147.5	2.7	3.983	298.5	3.1	9.254	153.25	4.15	6.360	233.25	3.15	7.347	184.5	3.25	5.996
After 2d	126.5	3.25	4.111	288.25	3.3	9.512	148.75	4.25	6.322	199.25	3.00	5.978	183.00	3.5	6.405

TABLE III — LOT II.

Grain Food and Tallow Consumed.

WEEK.	CLARA.				DORA.				GAZELLE.				MAY 2D.				NORA.			
	Grain.	Tallow.	Tallow per day.		Grain.	Tallow.	Tallow per day.		Grain.	Tallow.	Tallow per day.		Grain.	Tallow.	Tallow per day.		Grain.	Tallow.	Tallow per day.	
	Lbs.	Ozs.	Lbs.	Oz.	Lbs.	Ozs.	Lbs.	Oz.	Lbs.	Ozs.	Lbs.	Oz.	Lbs.	Ozs.	Lbs.	Oz.	Lbs.	Ozs.	Lbs.	Oz.
Before, Oct. 19 to 26	56	....	...	...	56	....	...	...	56	....	...	...	56	....	...	...	56	....	...	...
1st, Oct. 26 to Nov. 2	56	50	..	$7\frac{1}{7}$	56	50	..	$7\frac{1}{7}$	56	50	..	$7\frac{1}{7}$	56	50	..	$7\frac{1}{7}$	52	42	..	6
2d, Nov. 2 to 9	56	104	..	$14\frac{6}{7}$	56	104	..	$14\frac{6}{7}$	56	104	..	$14\frac{6}{7}$	56	104	..	$14\frac{6}{7}$	36	58	..	$8\frac{2}{7}$
3d, Nov. 9 to 16	56	176	1	$9\frac{1}{7}$	56	176	1	$9\frac{1}{7}$	56	176	1	$9\frac{1}{7}$	56	176	1	$9\frac{1}{7}$	56	176	1	$9\frac{1}{7}$
4th, Nov. 16 to 23	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..
5th, Nov. 23 to 30	56	188	1	$10\frac{6}{7}$	56	224	2	..	56	188	1	$10\frac{6}{7}$	56	224	2	..	56	224	2	..
6th, Nov. 30 to Dec. 7	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..
7th, Dec. 7 to 14	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..	56	216	1	$14\frac{6}{7}$
8th, Dec. 14 to 21	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..
9th, Dec. 21 to 28	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..
10th, Dec. 28 to Jan. 4	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..	56	224	2	..
After, 1st, Jan. 4 to 11	56	....	...	...	56	....	...	...	56	....	...	...	56	....	...	...	56	....	...	...
After, 2d, Jan. 11 to 18	56	....	...	...	56	....	...	...	46	....	...	...	56	....	...	...	56	....	...	...

Gazelle, grade Jersey, 6 years and 9 months old, in milk 1 month.

May 2d, $\frac{7}{8}$ Holstein, 1 year and 11 months old, in milk 1 month.

Nora, $\frac{7}{8}$ Holstein, 2 years and 1 month old, in milk 20 days.

The details of the experiment with the second lot were in all respects the same as with the first, except that they were on the winter feed for a greater part of the time and that the grain fed to the second lot was composed of 8 pounds of a mixture one-fourth bran and three-fourths gluten meal by weight, and in the feeding we were able to get the cows upon the full feed of 2 pounds of tallow each per day in the third week instead of the fourth. The amount of feed consumed is shown in Table III. No difficulty was found in getting the animals to eat the tallow. The health of all of the animals remained good and no appreciable change in live weight took place.

It will be seen that the tallow was readily and regularly eaten by nearly all of the animals. The exceptions were that Clara and Gazelle only ate a pound and a half per day during the greater part of the fifth week and Nora refused a part of two feeds in the seventh week. The yield in milk and fat of Lot II is shown in Table IV.

It will be seen that, as with Lot I, there were no variations in the percentage of fat that could be ascribed to the effect of the tallow. At least, there was no increase. The greatest change in percentage of fat was seen in the gradual decrease in the two two-year-old Holstein heifers, May 2d and Nora. There were two fluctuations in the percentage of fat in the cows in both lots, but they were intermittent and not progressive.

The time of the experiment fell very naturally into four divisions or periods:

First. The period of one week before beginning to feed the tallow.

Second. The preliminary period of three or four weeks during which the amount of tallow fed was gradually increasing.

Third. The period of full feeding, six or seven weeks.

Fourth. The final period of two weeks after the tallow was taken away.

In table V the average yield of milk per day for each cow and the average per cent. of fat for the whole period is grouped together, and to this has been added the average yield of milk per day and percentage of fat two months after the close of the experiment.

TABLE IV — LOT II.

Yield of Milk and Fat (by weeks).

WEEK.	CLARA.			DORA.			GAZELLE.			MAY 2D.			NORA.		
	Yield of milk. Lbs.	Average per cent. fat.	Yield of fat. Lbs.	Yield of milk. Lbs.	Average per cent. fat.	Yield of fat. Lbs.	Yield of milk. Lbs.	Average per cent. fat.	Yield of fat. Lbs.	Yield of milk. Lbs.	Average per cent. fat.	Yield of fat. Lbs.	Yield of milk. Lbs.	Average per cent. fat.	Yield of fat. Lbs.
Before	132.25	4.71	6.234	230.5	2.83	6.528	178.5	5.69	9.077	156.00	3.03	4.726	179.25	3.64	6.540
1st	120.00	5.05	6.039	219.75	3.1	6.822	170.75	5.15	8.803	143.75	3.05	4.381	159.25	4.60	6.386
2d	119.5	5.25	6.290	222.5	3.25	7.235	170.5	5.3	9.036	141.25	3.11	4.390	144.5	3.28	4.743
3d	85.5	5.83	4.982	236.5	3.2	7.558	176.5	4.86	8.575	152.00	2.85	4.333	167.00	2.77	4.630
4th	92.00	4.64	4.272	194.00	2.76	5.357	178.5	5.07	9.053	149.75	2.37	3.555	164.00	2.62	4.301
5th	91.75	4.72	4.327	174.75	2.8	4.900	153.75	5.15	7.925	133.00	2.34	3.115	149.75	2.59	3.883
6th	91.75	5.02	4.608	213.75	3.14	6.705	156.75	5.34	8.375	145.5	2.62	3.813	139.75	2.98	4.162
7th	95.75	4.5	4.309	217.5	3.2	6.960	148.5	4.75	7.054	144.5	2.45	3.540	140.25	3.15	4.418
8th	106.5	4.2	4.473	224.25	3.2	7.166	155.5	5.00	7.775	135.5	2.25	3.049	151.5	2.65	4.015
9th	99.25	4.15	4.119	212.00	2.75	5.830	153.25	5.00	7.663	132.5	2.25	2.981	152.75	2.55	3.895
10th	88.25	4.7	4.148	190.00	2.9	5.510	131.25	5.00	6.563	136.25	2.65	3.611	150.00	2.65	3.975
After, 1st	103.25	4.00	4.130	200.75	2.9	5.822	137.5	4.6	6.325	146.00	2.7	3.942	160.5	2.55	4.093
After, 2d	101.25	4.8	4.860	218.5	2.95	6.446	136.5	4.7	6.416	152.25	3.15	4.796	172.00	3.00	5.160

TABLE V — LOT I.

Summary by Periods.

PERIOD.	EMMA.		FREDDIE.		GARNET VALENTINE.		PEARL.		PET.	
	Pounds milk per day.	Average per cent. fat.	Pounds milk per day.	Average per cent. fat.	Pounds milk per day.	Average per cent. fat.	Pounds milk per day.	Average per cent. fat.	Pounds milk per day.	Average per cent. fat.
I. One week, before feeding tallow, Sept. 14 to 21.......	30.29	3.49	47.21	3.52	25.93	4.41	36.57	3.11	35.89	3.63
II. Four weeks, preliminary amt. of tallow increasing, Sept. 21 to Oct. 19............	27.78	3.45	47.07	3.54	25.45	4.83	34.79	3.39	35.56	6.77
III. Six weeks, on full feed of tallow, Oct. 19 to Nov. 30...	23.64	2.84	42.43	3.24	21.50	4.73	32.71	3.26	26.95	3.79
IV. Two weeks, after feeding tallow, Nov. 30 to Dec. 14...	19.57	2.95	41.91	3.20	21.57	4.20	30.89	3.08	26.25	3.37
Two months afterward, week ending Feb. 14..........	20.36	3.1	42.14	3.3	17 82	5.00	29.07	3.35	8.61	4.00

TABLE V — LOT II.

Summary by Periods.

PERIOD.	CLARA.		DORA.		GAZELLE.		MAY 2D.		NORA.	
	Pounds milk per day.	Average per cent. fat.	Pounds milk per day.	Average per cent. fat.	Pounds milk per day.	Average per cent. fat.	Pounds milk per day.	Average per cent. fat.	Pounds milk per day.	Average per cent. fat.
I. One week, before feeding tallow, Oct. 19 to 26	18.89	4.71	32.93	2.83	25.50	5.09	22.29	3.03	25.61	3.64
II. Three weeks, preliminary, amt. of tallow increasing, Oct. 26 to Nov. 16.......	15.48	5.33	32.32	3.18	24.65	5.10	20.81	3.00	22.42	3.35
III. Seven weeks, on full feed of tallow, Nov. 16 to Jan. 4 .	13.58	4.55	29.10	2.98	21.99	5.05	19.94	2.42	21.38	2.73
IV. Two weeks, after feeding tallow, Jan. 4 to 18	14.60	4.35	29.95	2.93	19.57	4.65	21.30	2.93	23.75	2.78
Two months afterward, week ending March 18	13.68	5.5	33.43	3.00	17.00	4.9	19.25	3.05	24.14	3.2

In table V it is seen there is no very marked change in the percentage of fat and yield of milk in the period when the cows were on a full feed of tallow. While there are slight variations in the percentage of fat, they rarely reach one-half of one per cent. and what is of more significance they are not uniform. Some of the cows gave richer milk and some poorer on a full feed of tallow than they did before or after.

It is of interest to note the average daily yield of milk and the percentage of fat for each cow two months after the close of the experiment which is included in Table V. It will be seen that all the cows except Pet were still giving practically the same amount of milk of the same quality, and Pet at this time had practically reached the end of her period of lactation.

CONCLUSION.

In this quite extended trial there has been no increase in the fat in the milk by feeding tallow to the cows in addition to a liberal grain ration. These results were obtained with ten different cows, of two breeds of various ages, in various periods of lactation, extending over a period of ten weeks, for at least six of which they ate two pounds per head, per day of tallow.

HENRY H. WING.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals. Season of 1895.

Frequent inquiries lead us to believe that the following information is timely:

	1895. Cents per pound.	1894. Cents per pound.
Nitrogen in ammonia salts	18½	19
Nitrogen in nitrates	15	14½
Organic nitrogen in dry and fine ground fish, meat, blood, and in high-grade mixed fertilizers	16½	18½
Organic nitrogen in cotton-seed meal	12	15
Organic nitrogen in fine ground bone and tankage	16	16½
Organic nitrogen in fine ground medium bone and tankage	14	15
Organic nitrogen in medium bone and tankage	11	12
Organic nitrogen in coarse bone and tankage	5	7
Organic nitrogen in hair, horn shavings, and coarse fish scraps.	5	7
Phosphoric acid soluble in water	6	6
Phosphoric acid soluble in ammonium citrate	5½	5½
Phosphoric acid in fine bone and tankage	5½	5½
Phosphoric acid in fine medium bone and tankage	4½	4½
Phosphoric acid in medium bone and tankage	3	3
Phosphoric acid in coarse bone and tankage	2	2
Phosphoric acid in fine ground fish, cotton-seed meal, and wood ashes	5	5
Phosphoric acid insoluble (in am. cit.) in mixed fertilizers	2	2
Potash as high grade sulphate, and in mixtures free from muriate	5¼	5
Potash as muriate	4½	4½

The manurial constituents contained in feedstuffs are valued as follows:

Organic nitrogen	15	15
Phosphoric acid	5	5
Potash	5¼	5

In applying the foregoing prices to the guaranteed analysis of a commercial fertilizer it should be remembered that no allowance has been made for mixing the fertilizer, commission or freight to interior points, as the prices given are the average wholesale prices in the larger cities on the Atlantic sea board for six months previous to March, 1895.

It should be remembered that ammonia is 82.3 per cent. nitrogen; that sulphate of potash is 54. per cent. actual potash, and muriate (chloride) of potash 63.5 per cent. actual potash.

In buying and applying commercial plant food the following brief rules may be adhered to in the majority of cases:

Chemicals or mixed fertilizers of high grade furnish cheaper plant food than those of a low grade.

Wherever a good crop of clover or other leguminous plants can be grown they will produce nitrogen cheaper than it can be obtained in commercial fertilizers.

Well-drained upland soils are usually defient in nitrogen but not in phosphoric acid.

Reclaimed low lands are frequently deficient in phosphoric acid but contain an abundance of nitrogen.

Muriate of potash should not be applied to sugar beets, tobacco or potatoes.

Fruit trees making a yearly growth of from six inches to one foot do not need nitrogen but are usually benefited by a moderate application of potash and phosphoric acid.

The greater the leaf surface of a plant the more potash it requires.

Nitrogen salts should be applied only in such quantities as meet the requirements of the crop, on account of the liability of loss from leaching.

Nitrates should always be applied on the surface to a growing crop.

BULLETIN 93—May, 1895.

Cornell University—Agricultural Experiment Station.
ENTOMOLOGICAL DIVISION.

THE CIGAR-CASE BEARER

IN WESTERN NEW YORK.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in Western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. On the Effect of Feeding Fat to Cows.
93. The Cigar-Case Bearer.

Cornell University,
Ithaca, N. Y., *April* 18, 1895.

The Honorable Commissioner of Agriculture, Albany:

Sir.— One of the serious insect pests which we met when prosecuting our investigations of the apple orchards of western New York last year, is the Cigar-case Bearer. A brief sketch of this insect was given in Bulletin 84, and the present paper is the account which was promised in that bulletin. Mr. Slingerland has made a very careful study of the insect, and this account of it is approved by Professor Comstock. This case bearer will probably take its place along with other staple pests which, by harrying the apple grower, will hasten the study and improvement of our orchard interests; and this bulletin is therefore recommended for publication under Chapter 230 of the Laws of 1895, as an important contribution to the advancement of apple cultivation.

L. H. BAILEY.

BIBLIOGRAPHY.

1889. Lintner. Fifth Report, p. 324. Received specimens from Rochester, N. Y., at work on young pears, June 8, 1888. (As *Coleophora* sp.)

1890. Lintner. Popular Gardening, v. 198. Brief account of its work on young pears; early arsenical spray advised. (As *Coleophora* sp.)

1891. Lintner. Sixth Report, p. 347. Same as 1890 account above.

1892. Fletcher. Report for 1891, p. 196–198. Good account of habits and spraying experiments. (As *Coleophora* sp.)

——. Fletcher. Evidence before Com. of House of Commons, p. 9. Brief account of habits and experiments against. (As *Coleophora* sp.)

——. Fernald. Canadian Entomologist, xxiv, 122. Original description of moth; case also described. (As *Coleophora fletcherella.*)

1893. Fletcher. Report for 1892, p. 4. Brief mention.

——. Lintner. Ninth Report, p. 374. Brief mention.

1894. Fletcher. Twenty-fifth Report of Ont. Ent. Soc., p. 79,80. Best account of life history and remedies.

——. Fletcher. Evidence before Com. of House of Commons, p. 19. Brief account.

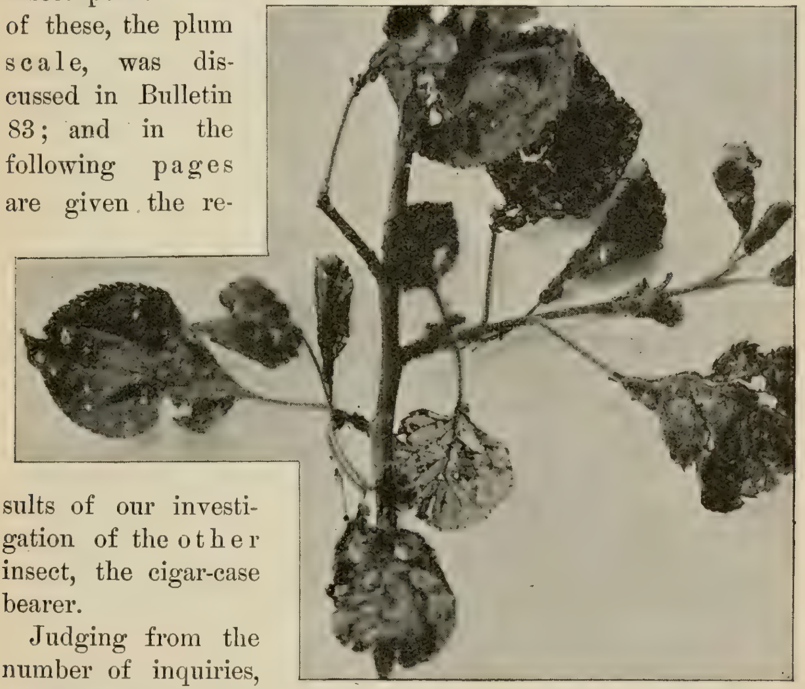
1895. Fletcher. Report for 1894, p. 201–206. Habits and life history; remedies.

The Cigar-case Bearer.

Coleophora fletcherella Fernald.

Order LEPIDOPTERA; superfamily TINEINA.

During the past year (1894) fruit trees in western New York have suffered severely from the attacks of two, practically new, insect pests. One of these, the plum scale, was discussed in Bulletin 83; and in the following pages are given the results of our investigation of the other insect, the cigar-case bearer.



54.—Work of the Cigar-case bearer on apple foliage, June 14. (From Bailey.)

Judging from the number of inquiries, with their accompanying specimens, that reached the insectary in 1894, this case bearer was one of the most serious pests of the season. Professor Bailey's observations, recorded in Bulletin 84, p. 15, also show that the insect was very destructive, especially in the apple orchards in Wayne and Monroe counties. Fig. 54 is a fair sample of its destructive work on apple foliage; many of the smaller leaves are dead, and the others are almost entire skeletonized by the insect. We have no definite data as to just how much damage the insect did in 1894. Apparently it now ranks next to the bud-moth (Bulletin 50) in destructiveness ; and the two insects are often seen at work on the same branches.

Thus this new case bearer affords an additional emphasis to the fact that eternal vigilance on the part of the fruit grower is now the price which must be paid for the finest and best fruit.

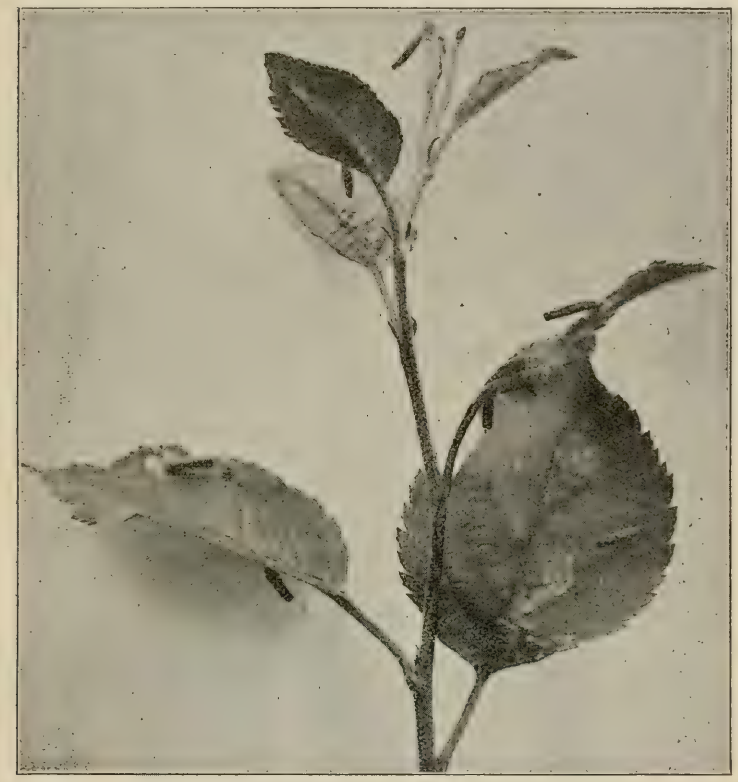
ITS PAST HISTORY AND DISTRIBUTION.

Doubtless this case bearer has been present in limited numbers in New York orchards for many years; and it may have been previously noticed by some fruit growers, but it was not until 1888 that public attention was called to it, by Mr. P. Barry of Rochester, N. Y. He found it boring holes in newly-set pear fruits, and specimens were sent to Dr. Lintner; these specimens furnished the text for the first published account of the insect, by Dr. Lintner in 1890. In 1892 Dr. Lintner received some apples from Oswego N. Y., which had apparently been bored by this case bearer.

Nothing further seems to have been heard of the insect in our State until last year (1894.) Then specimens began to come into the insectary from western New York as early as February, and continued coming in increased numbers during the months of May and June. Specimens were received from the following localities: Rochester, West Brighton, Moreton Farm, North Rose, Albion, Newark, Sodus and South Byron ; this winter we have also received specimens from North Parma, and have seen the insect here in Ithaca. The specimens sent in indicated that it was present in alarming numbers in nearly every case. Doubtless it will be found generally distributed throughout the State, and it probably also occurs in neighboring States.

The insect is also very numerous in Canada. It first attracted attention there in 1889 at Charlottetown, Prince Edward's Island. In 1891, it appeared in alarming numbers at Adolphustown, Ontario ; and a few were also found at Port Williams, Nova Scotia. Last year it did very serious damage in several localities in Ontario ; specimens were also sent to the insectary from Lakeville, Nova Scotia.

Thus, this case bearer has so far been recorded only from New York and Canada, and has appeared in alarming numbers only in western New York and Ontario. Attention was first directed to the insect at about the same time in the widely separated localities of Rochester, N. Y., and Prince Edward's Island. It was especially destructive in Ontario in 1891 and in both New York and Ontario in 1894; and, judging from specimens received this winter, hundreds of the little creatures are passing through their long winter's fast safely, and will be ready to satisfy their hunger on the opening buds of thousands of fruit trees in western New York in the spring.



55.—Cigar-case bearers at work; natural size.

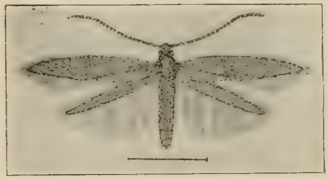
ITS APPEARANCE.

On account of its small size and peculiar habits, the insect itself, in any stage, will rarely be noticed by the fruit grower. But one of the curious suits, or cases as they are called, which the little caterpillar wears is quite conspicuous, thus often revealing its presence to even the casual observer.

The Caterpillar and its Curious Case.— The caterpillars are their own tailors and each has two suits during its life time. The first suit or case is made in the fall, when the caterpillar is about two or three months old; it is worn all winter and until about May 15th of the next spring. As this case is quite small, it is often overlooked by the fruit grower. This phase of the insect's life is discussed in detail further on under the account of its life history.

About May 15th the half-grown caterpillar finds that its winter suit is too small, and proceeds to make a new and larger summer case; we caught the little tailor at this work one morning, and a photograph of the interesting process is presented further on, with an account of the operation. This second case presents a striking resemblance to a miniature cigar, both in its shape and color. In May or June one or more of these curious cigar-shaped cases may often be seen projecting at various angles from a leaf (Fig. 55) or from a young fruit (page 281); and as the figures show, they are quite conspicuous objects. They are sure to arouse one's curiosity, especially when, after watching one for a few minutes, it is seen to move off to another part of the leaf. A careful examination of one of these moving, cigar-like objects will reveal its inhabitant, a dark orange-colored, black-headed caterpillar scarcely one-fifth of an inch in length. When disturbed, the little creature retreats into its cigar-shaped case, and can be induced to come forth only by either tearing open its case or by continued urging from the rear. As described in detail further on in discussing its life history, the insect passes the remainder of its life until the emergence of the adult in this cigar-shaped case.

The Adult Insect.— The moth, shown nearly four times natural size in Fig. 56, is a very delicate and pretty steel-gray object. During the day it rests on a leaf with its heavily fringed wings folded closely over its abdomen and its long slender antennæ placed close together and projecting straight forward from its head. They may be seen on the leaves from about June 15th to July 15th.

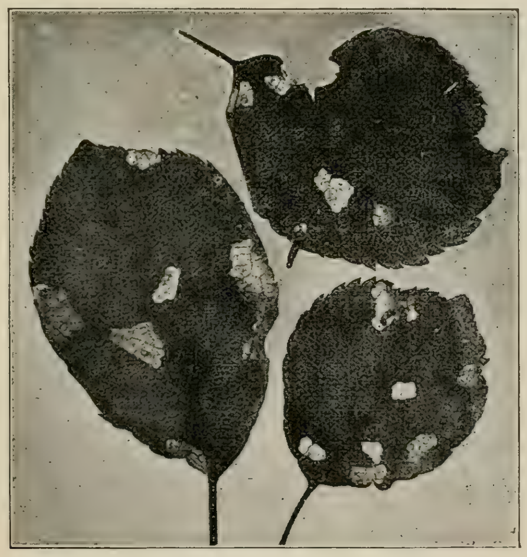


56.—Adult insect, about four times natural size.

INDICATIONS OF THE PRESENCE OF THE INSECT.

The first indications of the presence of this case bearer appear on the swelling buds of apple, pear, or plum trees. Early in the spring of 1894, we saw hundreds of them at work on pear buds near Rochester, N. Y.; they were then in their small curved cases (Fig. 59), and were quite conspicuous as they projected from the surface of the swelling buds. Two or three often occurred on a single bud busily at work eating minute round holes, scarcely larger than a pin, into the buds. The buds open quite rapidly, and an many of the caterpillars do not awaken from their winter's sleep thus early in the season, the damage done on the opening buds is small compared with their later work on the foliage.

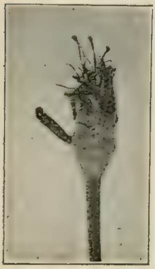
The work of the insect on the expanded foliage takes the form of various sized, skeletonized, dead, and brown areas which have near their centers a clean cut small round hole through one skin (usually the one on the underside) of the leaf. These skeletonized areas are well shown in Fig. 57. When the insect is very numerous, often so much of the inner tissue of the leaf is thus eaten out that the whole leaf turns brown and dies. Several of the leaves on the branch shown in Fig. 54 were killed in this way, and several of



57.—Characteristic work of the caterpillars on the leaves; natural size.

the others almost entirely skeletonized. Thus the work of the case bearer on the foliage is quite conspicuous, and may be easily recognized with the aid of the figures.

The caterpillars also often attack the forming fruit. In fact, the insect first attracted public attention by its work on the fruit of pears; Dr. Lintner has also found their work on apples. The frontispiece well illustrates their work on the fruit. The caterpillar eats a circular hole through the skin and then revels in the flesh beneath, sometimes eating as far as it can reach and not let go of its case. Our observations indicate that after the fruit attains about twice the size of the one shown in the frontispiece, it is but little injured by the attacks of this case bearer* But, as Mr. Fletcher states, the insect also attacks the stems of the flowers and setting fruit, and often does much damage in this way. Fig. 58 shows a young pear which was killed by the case-bearer attached to it; we received this specimen from Albion, N. Y., on May 29, 1894.



58 — A cigar-case bearer attached to a young pear which it had killed; natural size.

Thus the presence of this case bearer may be indicated, not only by its peculiar appearance, but by its eating minute holes in the swelling buds, by its skeletonizing irregular areas on the leaves, by its attacking the stems of the flowers and setting fruit, or by the destruction of the young fruit itself.

ITS NAME.

The striking resemblance of the larger case, which the caterpillar carries about with it, to a minature cigar, suggested to Mr. Fletcher the apt popular name of Cigar-case bearer for this insect.

It belongs to the large group of minute moths known as Tineids; nearly all of the Tineids are easily distinguished from other moths by their narrow wings, which are bordered with very wide fringes (Fig. 56). When Dr. Lintner first saw this case bearer in 1888, he referred it to the Tineid genus *Coleophora.* It was not until 1892, however, that it received a specific name. Then Dr. Fernald named it *fletcherella*, in honor of Mr. Fletcher, who gave us the first extended account of its habits and life history. Thus, the insect is scientifically known as *Coleophora fletcherella.*

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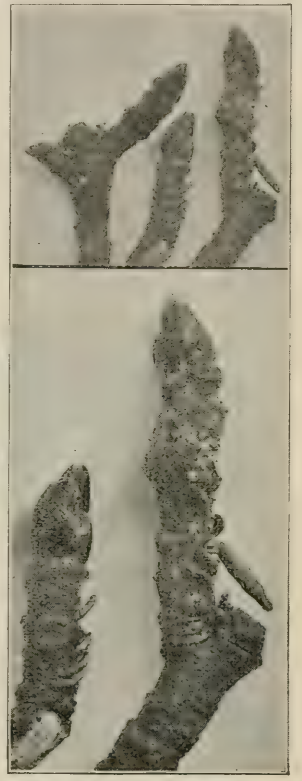
* Several larvæ were placed under a net on pears on a tree near the insectary; and although they punctured the fruit in several places, in every case the scar healed and was scarcely visible on the mature fruit. It is doubtful if this case bearer has anything to do with the hard knotty kernels which are so often accompanied by irregular pustular spots or cracks; this mysterious affection which was so prevalent on the fruit in many pear orchards in western New York in 1894, may be the work of plant bugs or of the plum curculio.

ITS LIFE HISTORY.

This little case bearer is one of the most interesting insects, as regards its life history and habits that it has been our pleasure to study. It has been under almost daily observation here at the insectary from the time it awakes from its winter's sleep until it passes through its wonderful transformations into the delicate little moth, from whose beautifully sculptured eggs the little caterpillars hatch; and these soon demonstrate that they are both miners and tailors. We have also been fortunate enough to secure pictures of some of the most interesting phases of its life; no illustrations of the insect or its work have heretofore been publshed.



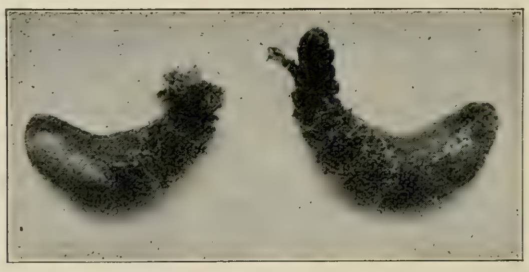
59.—The small curved cases in which the caterpillars hibernate on the twigs; the upper part of the figure is natural size, while the two lower twigs are twice natural size.

Hibernation.—By September 15th most of the little creatures have gone into winter quarters as minute, half-grown, orange-yellow caterpillars encased in a small curved suit, and firmly attached to the bark, usually on the smaller branches. In Fig. 59 are shown many of the insects in hibernation; the upper part of the figure shows the cases natural size. The large case so conspicuous on the right hand twig is one of the cigar-shaped cases fastened there during the summer by a mature caterpillar; it serves well to contrast the two suits worn by the caterpillars during their lifetime. Where the insect is numerous, they may be quite easily discovered in their winter quarters; the specimens figured were recently sent in by a correspondent at North Parma, N. Y.

Nearly seven months of the insect's life is spent in idleness in these snug, curved cases on the twigs of the trees.

Appearance and Habits in the Spring.—The little caterpillars awake from their long winter's fast early in the spring, as soon as the buds begin to open. In 1894, the little cases were loosened from the twigs about April 15th, and the march of the hungry caterpillars for the buds began; on April 25th we saw hundreds of them on pear buds near Rochester. Their manner of working on the buds has been described on page 289.

As the caterpillars continue feeding on the expanding foliage they soon find that their winter suits or cases are too short for their growing bodies; and they proceed to build on extensions at one end. In Fig. 60 are shown, considerably magnified, two of these enlarged spring suits or cases; from one, the head of the caterpillar projects. The smoother portions of the cases in the figure represent the winter suits. The portions added in the spring are much rougher, apparently consisting of bits of the fuzzy skin of the young leaves glued together; in many cases this added portion is nearly as long as the original winter case.

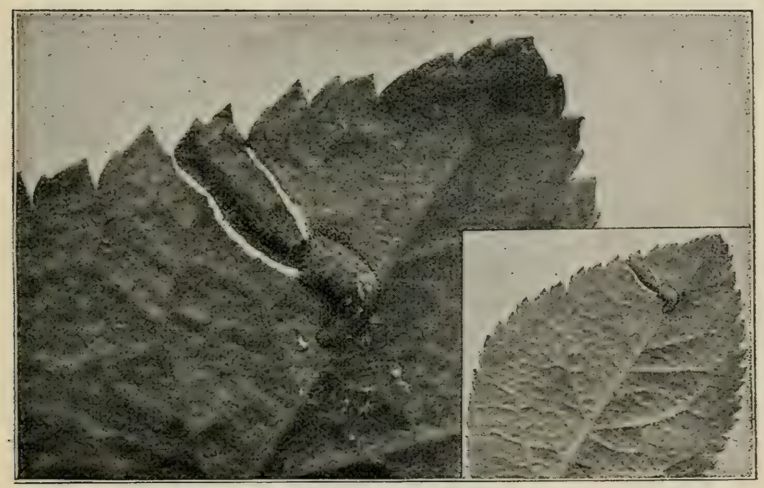


60.—The winter cases, with their spring additions; much enlarged.

However, the little caterpillars increase in size so fast in the spring, that by the middle of May most of them find their spring suits entirely inadequate for their wants. Then their tailoring instinct again asserts itself and they proceed to construct their second and last suit or case.

The Construction of its Cigar-shaped Suit or Case.—In the construction of this, its summer suit, the caterpillar illustrates in a very interesting manner the instinctive powers of insects. We were fortunate enough to catch one of the little tailors at work on its new suit, and the camera has faithfully reproduced what we saw (Fig. 61).

During the forenoon of May 31st, we found one caterpillar that was still in its spring suit or case. It was transferred to a fresh leaf, where it at once traveled to a point on the underside a short distance from the edge. There work was begun by first eating a small round hole through the skin of the leaf; it then began feeding upon the inner tissues between the two skins of the leaf. By nightfall it had thus eaten out the tissue over a narrow elongate area reaching to the edge of the leaf. The little tailor must have continued its work nearly all night, for at eight the next morning what we saw is represented, considerably enlarged in figure 61; the leaf in the lower right hand corner is natural size. The caterpillar had mined out the inner tissue over the narrow area, for the purpose of using the two skins of the leaf remaining above and below the mined area, as the cloth out of which to make its new suit. As the figure shows, the little tailor had then adroitly cut out his suit by cutting through both skins along the sides of the mine, leaving a few strands uncut to act as guy ropes to hold the skins in position while they were being neatly joined together by the silken threads spun by the caterpillar inside. The stocking-shaped object shown on the leaf in the figure is the caterpillar's discarded spring

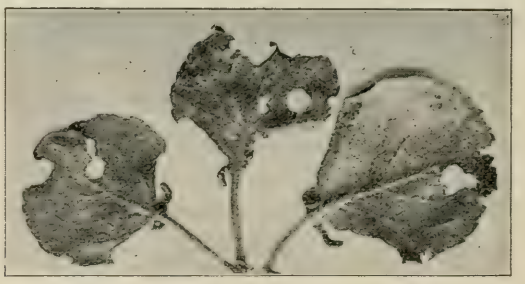


61.—The little tailor at work making its summer cigar-shaped suit; much enlarged, except the leaf in the corner, which is natural size.

suit. When the photographs for Fig. 61 were taken, the caterpillar was busily at work spinning a smooth silken lining in its new suit. At this stage of the proceedings, it became a martyr to science and the whole leaf now forms an interesting addition to our collection illustrating the different phases of this curious case bearer.

When first sewn together, the two skins of the leaf make a flattened case. This is gradually constricted into the more rounded cigar shape, doubtless by the caterpillar in tightening his silken lining inside. The round hole eaten through the skin of the leaf when the mine is begun, now serves as the entrance to the new case. When the case is complete, the caterpillar in some manner manages to break the now dry and brittle guy ropes, and elevating its new suit in the air walks off to seek new pastures, leaving the little empty case attached to the leaf. These cigar-shaped cases, being thus formed from bits of the upper and lower skins of a leaf, show, under a lens, on one side the characteristic raised veinlets of the upper skin and on the other the fine hairs of the lower skin. Usually the side seams form slight ridges on the case.

Our wonder at the ingenious tailoring which the little caterpillar did in our cage was increased, when, upon further examination of many infested leaves sent in by correspondents, we found that most of them had shown still more ingenuity in their work. Many of the leaves received May 31st had had their basal edges eaten away in a peculiar manner; and the explanation was always at hand in the form of one of the little curved cases, always empty, attached at the point where the leaf joins its stem. In Fig. 62 are shown three such leaves natural size; quite often both basal edges would be cut away, as shown in the figure.

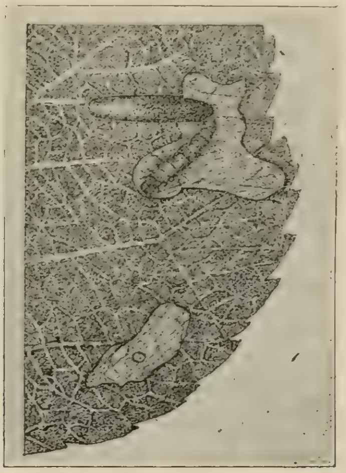


62.—Leaves whose basal portions were used by the caterpillars in making their cigar-shaped cases; natural size.

Why should the caterpillars always seek this particular portion of the leaf from which to make their cases? Mr. Stainton tells us it is for the simple reason that the little tailor saves itself much trouble by thus mining at the edge of the leaf, because the upper and lower skins are already joined together along one side, the edge of the leaf, and the making of one seam is thereby avoided.*

At the uper end, these cigar-shaped cases are contracted rather abrubtly into a three-lipped, star-shaped orifice, the lips of which fit closely together. This orifice, or back door, is used for a special purpose by the caterpillar, as we shall see later.

Its Habits as a Cigar-Case Bearer.— Most of the caterpillars finished their cigar-shaped summer suits by May 25th, in 1894. After this date, they feed mostly on the leaves, and do their most damaging work during the next three weeks. The peculiar manner in which they feed is well shown in Fig. 63. A small hole is eaten through one skin of the leaf and the soft inner tissue is then mined out. The caterpillar protrudes itself from its case and feeds as far as it can reach in several directions, thus forming an irregular blotch mine. The little miner never lets go of its case while at work, and quickly wriggles back into it when disturbed. Many of these blotch mines with their entrance holes are shown in figure 57. The



63.—A caterpillar feeding; much enlarged.

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*Natural History of the Tineina, by H. T. Stainton. Vol. iv, Coleophora, part I, p. 8. (1859.)

caterpillar keeps the interior of its home neat and clean by using the small hole in the upper end of the case as a back door out of which all of the excrement is ejected.

Some of the caterpillars become full grown by June 4th, but most of them continue feeding until about June 20th. They then seek a suitable place, usually on the leaves but sometimes on the branches, where they securely fasten their case with silk, in nearly the same position in which the caterpillar holds it while feeding. So securely are they fastened that they remain in place long after they are of any further use to the insect; this fact accounts for the cigar-shaped cases sometimes found among the small curved hibernating cases on the branches in winter, as shown on the right hand branches in Fig. 59.

Pupation.— If one of these cigar-shaped cases be cut open about ten days after it was fastened as described above, there will be found inside, not the dark orange-colored caterpiller, but a light brown quiescent object, known as the pupa. Thus these cigar-shaped cases serve both as a summer suit for the caterpillar and as a secure cocoon within which the insect undergoes its tranformations to the adult stage.

After fastening its case, and before changing to a pupa, the caterpillar in some manner turns around in its case, for the head end of the pupa is always found nearest the upper end of the case.

Emergence of the Moth, and Egg-Laying.— About ten days after the change to a pupa takes place in cigar-shaped cases, there emerges through the lipped orifice in the upper end of the case a minute steel-grey moth—the adult insect (Fig. 56.) In our cages, some of the moth emerged as early as June 25th, but others did not appear until July 15th.

The moths remain at rest on the leaves during the day. They doubtless feed but little, if any, and do no damage. Some of the moths that emerged June 25th had laid eggs three days later. In our cages, most of the eggs were snugly tucked away among the numerous hairs on the undersides of the youngest leaves near the mid ribs; some were similarly laid on the young, hairy branches. They are apparently not glued to the hairs, as they are easily dislodged.

The eggs are of a delicate light lemon-yellow color, and quite deeply pitted over their entire surface with triangular depressions separated by narrow ridges (Fig. 64). They are cylindrical in shape with rounded ends, and measure .31 by .25 mm., thus being scarcely visible to the unaided eye. Under a lens they are beautiful objects. The egg stage lasts about two weeks, the little caterpillars emerging about July 15th.

64. — The egg; greatly magnified.

Mining Habits of the Recently Hatched Caterpillars.—The newly-born caterpillars are miners, and at once eat through one skin of the leaf and begin a mine in the soft inner tissue. They keep their mines clean as they go, by throwing all of their excrement out of the entrance hole. They continued to feed in this manner for about two weeks, or until August 3d, in our cages; then, owing to our inability to keep their food fresh any longer, they died.

Construction of their Winter Suit or Case, and the Full Migration of the Caterpillars.—After feeding as miners for two or three weeks, the young caterpillars exercise their tailoring instincts by constructing tiny curved cases in which they are to pass the winter. One of Mr. Fletcher's correspondents saw many of these little cases on the leaves on August 10th. We have not been able to catch the little tailor at its work of making its winter suit; but Mr. Fletcher says they cut clean holes through the leaves by taking oval pieces from the upper and lower skins of the leaves with which they form their curious cases by joining them together along their edges. Doubtless the process is similar to the one used in making the summer cigar-shaped cases, as shown in Fig. 61. These small curved cases (Fig. 59) also have an opening in the upper end out of which the caterpillars eject their excrement.

Probably they feed for several days on the leaves after they make these curved cases. About September 1st, migration begins from the leaves to the twigs, where they securely fasten their cases, which then serve as snug, warm and secure quarters for the winter. Many of these hibernating case bearers are shown in Fig. 59.

Briefly summarized, the life history of this case bearer is as follows: The insect spends about seven months (from September 15th to April 15th) of its life in hibernation as a minute half-grown caterpillar in a small case attached to a twig (Fig. 59). In the spring, the caterpillars attack the opening buds, the expanding leaves, the stems of the flowers and fruit, and the forming fruit

(Figs. 55 and 58). By May 20th, its hibernating case with its spring additions (Fig. 60) is discarded for another and larger cigar-shaped case (frontispiece and Fig. 58) which the caterpillar deftly makes from pieces of the upper and lower skins of the leaves (Fig. 61). Protruding themselves from these cases, they eat through one skin of the leaf and mine out the inner tissues over an irregular area, as far as they can reach and not let go of their case (Fig. 63). In the latter part of June, they cease feeding, securely fasten the cases to the leaves or branches, and change to pupæ within. The moth (Fig. 56) emerges in about three weeks, and soon lays minute, pretty, yellow, pitted eggs (Fig. 64) among the hairs on the young leaves. The egg stage lasts about two weeks, the little caterpillars emerging about July 15th. They work as miners in the tissue of the leaf for two or three weeks, then abandon their mining habit and construct their curious little curved cases from bits of the skins of the leaves. By September 15th, they have all migrated to the twigs, where they pass the winter in these cases (Fig. 59).

NATURAL ENEMIES.

We have not met with any natural enemies of this case bearer, but in 1891, Mr. Fletcher bred a few minute hymenopterous (Chalcid) parasites from the cases in Canada.

HOW TO COMBAT IT.

It is practicable to fight this case bearer in its caterpillar stage only; and it is then so well protected in its case as to render its destruction dependent upon very thorough work.

Extensive experiments in Canada by Dr. Young, of Adolphustown, Ont., have demonstrated that there is but little hope of reaching the caterpillars while they are in their winter quarters on the twigs. Dr. Young sprayed his trees in the winter with kerosene emulsion, using it both cold and warm (probably diluting it with nine parts of water), and failed to destroy the caterpillars in their little cases. Perhaps a stronger emulsion might have been more effective, but it is very doubtful if any spray will reach the insect in its winter quarters. Thus the only time when it can be effectively reached is when it is actively feeding in the spring.

We have had no opportunity of carrying on any experiments against the insect; but we advised all of our correspondents in

1894 to spray thoroughly in the early part of June with Paris green, one pound to 200 gallons (always using two or three pounds of lime to prevent injury to the foliage from free arsenic.) Several reported very satisfactory results. The first spraying should be made as soon as the little cases are seen moving in the spring, that is, about the time the buds begin to open. Repeat the application from four to seven days later, for the leaves open fast and soon present much unpoisoned surface for the case bearers to work upon. In Canada, Dr. Young has had very good results from the Paris green thus applied.

Fortunately, this is just the time when the bud moth (discussed in Bulletin 50) can be the most successfully combated with the same spray. In fact, the cigar-case bearer and the bud moth often worked on the same leaves in many western New York orchards in 1894. The Paris green may be effectually combined with the Bordeaux mixture at this time for the first application for the apple-scab fungus.

While Dr. Young found the Paris green spray very effective, as mentioned above, he also discovered that a spray of kerosene emulsion, diluted with nine parts of water,* applied thoroughly in the spring when the caterpillars are active, was still more effective. Some of our correspondents have also thought they checked the bud moth with the emulsion used at this time for other insects. It is also a fortunate coincidence that the same emulsion spray, when directed against the case bearer in pear orchards, will also be just in time to catch the recently hatched nymphs of that dreaded pest, the pear psylla, discussed in Bulletin 44.

To summarize, we believe that this cigar-case bearer can be kept in check by two or three thorough sprayings with Paris green, one pound to 200 gallons of water. The first application, which may be effectively combined with the Bordeaux mixture then to be used for the apple-scab fungus, should be made as soon as the little cases are seen on the opening buds. A second, and perhaps a third, application may necessary at intervals of four to seven days on badly infested trees. These sprayings will also check the bud moth.

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*To make the emulsion, thoroughly dissolve one-half pound hard or soft soap in one gallon boiling water. While this solution is still very hot add two gallons of kerosene and quickly begin to agitate the whole mass through a syringe or force-pump, drawing the liquid into the pump and forcing it back into the dish. Continue this for five minutes or until the whole mass assumes a creamy color and consistency which will adhere to the sides of the vessel, and not glide off like oil. It may now be readily diluted with cold rain water, or the whole mass may be allowed to cool when it has a semi-solid form, not unlike loppered milk. This standard emulsion if covered and placed in a cool dark place will keep for a long time. In making a dilution from this cold emulsion, it is necessary to dissolve the amount required in three or four parts of boiling water, after which cold rain water may be added in the required quantities.

Furthermore, it has been experimentally demonstrated in Canada that a kerosene emulsion spray, applied at the same time as directed above for Paris green, still more effectively checks the case bearer; and we believe it would act likewise on the bud moth. In pear orchards, both this case bearer and the pear psylla can be effectively checked by the same emulsion spray when the leaves are opening in the spring. Never spray a fruit tree when it is in blossom.

Remember that success in any case will depend almost entirely on how thoroughly the spraying is done.

MARK VERNON SLINGERLAND.

BULLETIN 94—May, 1895.

Cornell University—Agricultural Experiment Station.
BOTANICAL DIVISION.

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DAMPING OFF.

By Geo. F. Atkinson.

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Damping Off.

"Damping off" is a disease of seedling plants which rots or disintegrates the tissues at the surface of the ground. The tissues thus changed weaken, lose their firmness and supporting power, and the seedling falls prostrate on the soil. The disease is wide spread and sometimes very common. It occurs not only in gardens and fields but is a very frequent attendant upon the culture of seedling plants in the forcing house or bed. The trouble is favored by damp soil, comparatively high temperatures, and humid atmosphere.

The term "damping off" is therefore indicative of one of the attendant conditions of the soil inducing the disease. While this popular expression is thus far significant of the trouble it is by no means the exact statement of the case. The plants do not damp off because of the abundant damp or moisture in the soil. The dampness encourages the growth of minute parasitic plants, not visible to the unaided eye, which pierce the seedling, feed upon its substance and set up disintegration processes which result in the death and collapse of the affected parts. Soon after the plant falls the dissolution of the tissues near the surface of the ground has usually proceeded so far that communication by the ordinary physiological processes of life is cut off, and the plant then withers and dies. While damping off is due to the action of minute fungus parasites, it is by no means caused by one and the same species. Different species of fungi may under some conditions produce nearly or quite identical phenomena in the progress and

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Frontispiece. — This is from a photograph of an experiment to show the parasitic nature of the Artotrogus debaryanus (Hesse). Before planting the cucumber seed the pots were filled with soil which was thoroughly wetted and then steamed in the steam sterilizer for several hours on three successive days in order to kill all the organisms. The seed was then planted and when just coming up some plant tissue with freshly developed stages of the fungus was placed by the seedlings in pots 5, 6 and 8, while pot 7 was left as a check. The result can be easily seen in the photograph, the check plants remaining unharmed while all the plants in 6 are killed and only one remains healthy in each of 5 and 8.

culmination of the disease. Some species develop phenomena allied to genuine cases of damping off, and the final result of which is practically the same, the decay of the stem near the surface of the ground and the collapse of the seedling.

Some variations in the external appearance furnish diagnostic characters correlated with the presence of certain species of the parasite, but it is doubtful if in any case the specific cause should be confidently asserted without recourse to microscopic examination, sometimes to be preceded by special treatment. In discussing the several species of fungi which have been found to contribute a share in the production of the disease it will be convenient to take up first the species to which the trouble is generally attributed, and then to follow with others which play a more or less important part in the development of similar or nearly identical troubles.

THE POTTING BED FUNGUS.

Artotrogus debaryanus [1] (Hesse).

This fungus is responsible for a large part of the damping off of young seedlings. It is very widely distributed, being very common in the soil of gardens and also in the forcing house. It is common also in many fields, but it probably is more abundant in soil where numbers of plants are grown from the seed in a more or less crowded condition, especially those plants which are known to be predisposed to its attacks. It has, however, been found in virgin soil taken freshly from the woods into the forcing house.[2]

It is thus a very common and unwelcome bedfellow and pot-companion of many seedling plants which are more or less crowded in the seed bed or forcing pots of our gardens and hot houses, especially if undue moisture is present in the soil. In the gardens it is frequently impossible to control the amount of moisture in the soil, and in the forcing house where often the light is defective, the air is not fresh or it is supercharged with moisture, it is often nearly or quite impossible by the ordinary methods to preserve that equilibrium of environment which will permit the growth of the seedling and at the same time check the growth of its inimical guest.

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[1] Pythium debaryanum Hesse. The name Pythium was used in 1823 as a generic name for two species (Mucor spinosus Schrank, and M. imperceptibilis Schrank, Denkschr. d. k. acad. d. wiss. z. Munschen, 1813, 14) by Nees von Esenbeck Nova acta acad. Leop. XI, 2,515, which belong to another genus (Achlya, see Fischer, Rabenhorst's Krypt. Flora. IV, 332). Artotrogus (Montagne, Sylloge, 304, 1845) was the next name which was used for a member of this group and must consequently take the place of Pythium Pringsheim, Jahrb. wiss. Bot. II, 303, 1860.

[2] Humphrey, 8th Ann. Rept. Mass. St. Agr. Exp. Station, 221, 1860.

All experienced gardeners are probably familiar with the appearance of the diseased seedling when affected with the damping off fungus. At this day when the germ theory of disease, both animal and plant, has so completely poisoned the minds of all classes of people there is little difficulty in successfully advocating what is now an established fact, that the damping-off fungus is a parasite in the seedlings and invades the tissue of the latter for the purpose of obtaining its food. It is fortunate, therefore, that especial attention can be given to setting forth the facts in the structure and development, and other peculiarities of the parasite, which are quite important to know in order to properly treat it, and also because it can then be distinguished from others either near or remotely related, some of which induce diseases in the early life of certain ferns or fern-like plants and can not disease seedlings.

The first striking pecularity in a bed or pot of seedlings affected with the disease which attracts our attention is the prostrate condition of a few plants while others are upright and apparently healthy. The prostrate plants are found to be shrunken at or near the crown, i. e. near the root or the surface of the ground. Frequently when our attention is thus first called to the disease the collapsed tissue of some of the prostrate plants is so far disintegrated as to be in a soft and rotted condition, so that on pulling at the plant it breaks easily at this point. Farther investigation will show that usually the entire root system is by this time decayed, while the greater part of the stem above ground and the young leaves are still green and possibly quite fresh, or flabby, or more or less wilted.

The conditions of the aerial portions of the plant at this early stage of its fall are largely dependent upon the moisture content of the atmosphere. If the moisture be quite dry the seedling will be quite flabby before it falls and will soon wilt thereafter, but if the moisture content is large the tissue will remain quite firm for a time unless the soil upon which it is lying is so saturated with moisture as to encourage the rapid growth of the fungus in the prostrate portion of the plant. When this is the case the entire plant soon becomes a putrid mass and the tissues often take on a dark color.

After attention has been called to the trouble by the preliminary collapse of a few plants, if others are carefully noted some will probably present a paler green color than the perfectly healthy ones, especially near the surface of the ground. If such plants are carefully examined they will probably show the presence of the fungus in the tissues of the root and lower part of the stem, for the fungus requires several hours after entering the tissues to produce such changes which would be visible to the unaided eye.

Mycelium.— If from one of these prostrate plants a portion of the collapsed part of the stem is teased apart on a glass slip, such as is used in microscopic work, in a little water and then examined under the microscope the vegetative phase of the parasite will probably be apparent. It exists as slender, colorless, thread-like irregular tubes, which appear to be more or less tangled in the tissues of the seedling. These tubes are the *hyphae*, as they are called, of the fungus, and collectively make up the *mycelium.* The hyphae are branched in quite a profuse manner, the successive branches usually forming somewhat more slender hyphae than the parent ones, so that the main hyphae is frequently larger than the branches.

The hyphae course between and through the cells. Where a hypha passes through a cell wall it is very much constricted or very much more slender than it is in the cell lumen of the seedling or between the cells. The hypha in boring its way through these walls excretes a ferment, it is supposed, which dissolves the cellulose of the walls at the point of contact. A quite minute opening in the wall is sufficient for the growing end of the hypha to squeeze its way through and maintain communication with the older portion, and has the advantage of requiring a much less expenditure of energy than if the opening were made of the same size as the hypha. After passing through the cell wall the hypha enlarges to the normal size.

While the mycelium is comparatively young the inner portion of the hypha is continuous, i. e., there are no cross walls partitioning the tubes into sections. This is a characteristic possessed by a very large group of fungi to which the *Artotrogus* belongs, known as the *Phycomycetes.* The protoplasm within the hypha is finely granular when the mycelium is young, but in the larger threads as they become older the granules become coarser, their contents are not so homogeneous, and the granules tend to collect into groups or very irregular masses, somewhat resembling the protoplasm in some mucors.

In a crowded seed bed after a few plants have fallen, unless the disease is checked, it will spread from these affected ones as centers to others near them and thus from the one or several starting points the plants will fall until nearly or quite all of them have been killed. Where the soil and atmosphere is quite damp and the temperature conditions so high as to favor rapid growth of the fungus it will grow out from the diseased part of the stem into or on the surface of the soil for a few millimeters in extent as a very delicate cottony mass or velvety pile. Where the adjacent plants are not too far distant the superficial threads may thus reach them and communicate the disease to them. In other cases minute motile reproductive bodies called *zoospores*, or *swarm spores* (perhaps more properly *zoogonidia*), are developed in a manner to be described later. These swim in the soil water to the more distant seedlings and thus spread the disease.

Sometimes there will be seen quite a profuse growth of a mycelium, which on the surface of the soil may spread several centimeters in extent. Usually this profuse growth is that of another fungus, a *Rhizopus*, or *Mucor*, or in other cases a different "damping off" fungus to be described in a later paragraph.

If the tissues examined as described above from a seedling which has not remained long after falling over perhaps the condition of the mycelium described will be the only phase of the plant (for the fungus is a plant) at that time present. If it has been dead for sometime, however, there will probably be seen here and there on the hyphae a number of rounded or spherical bodies, three to five times the diameter of threads of the mycelium with which they are connected. These are reproductive organs of the fungus and will soon be described.

The characters of the mycelium alone are not in all cases sufficient for the correct determination of the plant. Let then this preparation on the glass slip lie free in an abundance of water, and place the slip in a small, moist chamber sufficiently protected so that the air in the chamber will not become dry by evaporation at the point of contact of the two vessels. This can be avoided by placing a sheet of wet filter paper between the cover and the edges of the bottom vessel. A Petrie dish, such as is used in bacteriological work, is excellent for the purpose. Some wet filter paper should also be placed in the bottom and on this the support for the glass slip can be placed. For hasty examination the material can be teased out directly in the bottom vessel of the Petric dish in a little water, and then this can be placed on the stage of the microscope whenever it is desired to examine it.

In twelve to twenty-four hours if the preparation is again examined many threads of the fungus will be seen to have grown out from the tissue and spread on all sides for a distance of one to two millimeters in the surrounding water, now presenting the characters noted above in a clear manner, except there are no constrictions of the hyphae corresponding to those where they pass through the cell walls of the host. The branching is in an alternate or irregularly monopodial fashion. There will also be seen numbers of the rounded bodies noted above on the mycelium, both within the tissue and on the mycelium which is growing free in the water around its margin.

Sexual Organs.— Oogonia.—The larger number of these rounded bodies in the case of this species will probably be what are termed oogonia. These are developed in several relations to the hyphae which bear them. They may be terminal, i. e., on the ends of the hyphae which bear them, or on the ends of quite short branches, or intercalary, i. e., when they appear as swellings of the hyphae here and there without any reference to the end.

A terminal oogonium begins as a slight swelling of the rounded end of a hypha or short branch, which continues until the spherical body is about 18μ–25μ in diameter. During its growth in size the protoplasm which fills the interior is supplied by the supporting hypha or oogoniophore, without, however, emptying any portion of the latter structure. When the oogonium has reached its full size, a septum, or partition wall, is formed cutting off its protoplasm from that of the stalk or oogoniophore. At this time the wall of the oogonium is thin and the protoplasm finely granular, though distinctly so, and completely fills the interior of the oogonium. The wall now increases somewhat in thickness, but remains colorless.

The egg cell of the oogonium is now soon differentiated, and in most cases, except where parthenogenisis takes place, is probably influenced by the development of the antheridium. The finely granulated protoplasm of the oogonium becomes coarser and is gradually collected into numerous small irregularly rounded masses. At the same time all of the coarsely granular protoplasm contracts from the wall of the oogonium and moves toward the center forming there a rounded central mass somewhat less in diameter than that of the oogonium, being 14μ–18μ in dimeter. This central sphere of coarsely granular protoplasm is termed the oosphere, or egg cell, and is really an unfertilized egg, the receptive cell of the oogonium. Between this egg cell and the wall of the oogonium is a space filled with a nearly clear, but finely granular and homogeneous fluid called the periplasm. At this stage there is no wall surrounding the egg cell and it is ready to be fertilized.

Antheridia.—The sole purpose of the antheridia is to supply the fertilizing element for the egg cell, and the antheridium is sometimes termed the supplying gamete, while the oogonium is termed the receptive gamete. The antheridia are of two kinds, stalk antheridia and branch antheridia. A stalk antheridium is formed from a section of the oogoniophore by the formation of a partition wall in the hypha cutting off an elongated cell one end of which is thus in contact with the wall of the oogonium, and its contents are only separated from those of the oogonium by the wall of the latter. This is the simplest of the two forms of the antheridia.

A branch antheridium is developed as a lateral branch of the oogoniophore, arising, usually quite near the oogonium, but sometimes more or less remote from it, rarely on a separate hypha. The branch grows towards the oogonium and its rounded end comes in contact with the oogonium wall and becomes fixed at the point of contact. A septum is now formed in the branch cutting off an elongated cell varying from 15μ–40μ. This cell, one end of which is in contact with the oogonium wall, is the antheridium, and the proximal portion of the branch is the antheridiophore. More than one antheridium may be formed in connection with a single oogonium, frequently two and sometimes three. Both may be branch antheridia, or one may be a branch antheridium and the other a stalk antheridium, and other combinations may take place where more than two antheridia are present. There does not seem to be any rule in the number of antheridia which take part in the fertilization of the egg cell. Where several are in contact one or more may take part in the act of fertilization.

When the antheridial cell is formed its farther development is the same whether it be a branch an heridium or a stalk antheridium. The cell which is cylindrical or nearly so in form begins to swell and this continues until it is two to three times the original diameter, the greatest diameter being near the end which is in contact with the wall of the oogonium. At the same time it also becomes quite strongly curved and more or less twisted. In case the oogonium is a terminal one and possesses both a stalk antheridium, and branch antheridium, the stalk antheridium may curve so strongly to one side as to make it difficult to determine later which is really the stalk antheridium.

While these changes are taking place in the antheridium the granular protoplasm of the oogonium is moving toward the center to form the egg cell as described above, and now the end of the antheridium in contact with the wall of the oogonium, puts out a slender tube which pierces the oogonium wall, extends across the space occupied by the periplasm and touches the egg cell at the nearest point. This tube is known as the fertilization tube. At this point on the egg cell there is a small clear space called the receptive spot.

Nearly all of the protoplasm in the antheridum except a very thin layer next the wall becomes coarsely granular, arranged in strings and is finally collected in the middle line of the antheridium. This is known as the gonoplasm, and soon passes through the fertilization tube and is emptied into the egg cell at the receptive spot, where it disappears in the substance of the egg cell and completes the act of fertilization.

While the passage of the gonoplasm is going on it can be seen that a thin wall is forming around the egg cell over the surface except at the point where the fertilization tube is located. When the gonoplasm has passed through, the wall becomes complete at that point, and the entire wall then thickens somewhat and soon becomes brown in color. The fertilized egg cell now becomes the egg, or oospore.

These phenomena in the development of the oogonia and antheridia and in the fertilization of the egg cell can be quite easily followed by teasing out a small section of the diseased plant tissue in water on a cover glass and arranging this for a cell culture in what is known as a van Tiegham cell. This can be placed on the stage of the microscope from time to time and the development traced. From such a culture made from a diseased young melon seedling the following record was made. The diseased tissue was teased out in water on a glass slip Monday, January 28th, and placed in a moist chamber. The following day, January 29th, a profuse growth of mycelium, oogonia and antheridia had taken place, the mycelium extending for 2mm to 3mm out from the diseased tissue.

January 30th a small portion of this tissue was farther teased out and mounted in fresh water in a cell culture. January 31st farther growth had appeared and new oogonia and antheridia were developed. This continued for several days in the same culture.

On February 1st at 12.30 p. m. as shown in Fig. 1, the egg cell in the oogonium has formed and the antheridium curved over on one side is full size but the fertilization tube has not yet formed nor has the gonoplasm differentiated, the granular protoplasm being arranged in a network of threads. At 3.15 p. m. of the same day, as shown in Fig. 2, the fertilization tube is complete, the gonoplasm has formed and is about to pass through the tube, while a very thin wall is forming around the egg cell except at the receptive spot. At 9 p. m., Fig. 3, the gonoplasm has passed through and the wall of the oospore is complete. Fig. 4 represents an intercalary oogonium which was observed in the stage figured, at 12.30 p. m., February 1st. Two antheridia are here in contact with the oogonium, *s. a.* a stalk antheridium and *b. a.* a branch antheridium. In both cases the fertilization tube is complete, and the gonoplasm has separated preparatory to passing through. The curving of the stalk antheridium has turned the main thread to one side, the branch antheridium arising quite closely by the side of the oogonium has curved inward to the wall of this organ. At 3.30 p. m., Fig. 5, the gonoplasm has passed through the fertilization tube from both antheridia and a thin wall has formed around the now fertilized egg. Fig. 6 at 12 p. m., showed a terminal oogonium with two antheridia, one a stalk antheridium and one a branch antheridium, it being difficult in this case to say which is the stalk and which is the branch. An accident happened to this specimen and it was not seen again. Fig. 7 represents two terminal oogonia each with a stalk antheridum, first observed at 9 p. m., February 1st. At this time in the case of oogonium *a*, the egg cell is formed, and the gonoplasm in the antheridium has separated, while in oogonium *b*, the egg cell has not yet formed. From the fact that the stalk antheridium was on the under side of oogonium *b*, when it was first observed, the stage of its development could not be seen. At 2 p. m., on February 2d, however, fertilization was completed in both as shown in Fig. 8. Fig. 9 represents an oogonium with a fertilized egg and two antheridia in contact with its wall; one, *a*, a stalk antheridium whose gonoplasm took part in the act of fertilization, and one, *b*, a branch antheridium from a different hypha from that on which the oogonium is borne. From the latter the gonoplasm was not used.

These oospores or fertilized eggs mark a very important phase in the life history of the fungus. They will eventually germinate and produce the mycelium again, which under favorable conditions will start the disease anew. But the remarkable thing about the oospores is that they can not germinate immediately, except in rare instances, but must undergo a long period of rest, and hence are sometimes termed resting spores. In this condition they are capable of resisting degrees of cold and dryness which would prove fatal to the vegetative portion of the fungus. This accounts partly for the appearance of the disease after long periods of drought and after the inclement weather of the winter season in some sections.

Not only does the thicker wall of the oospore offer greater protection against an unfavorable environment, but the protoplasm undergoes a marked change before it finally enters upon this enforced period of rest. This change is practically a metamorphosis, the complete nature of which we do not understand. Among other changes there is probably a change in the molecular or physical structure of the protoplasm by which a large amount of a fatty substance is separated and forms a very large globule and sometimes other smaller ones which occupy a large part of the space of the oospore. The protoplasm thus becomes transformed into a state highly resistant to outside conditions and incapable of growth for a long period, even though the environment may be most favorable for growth. The period of rest lasts for several, four to five, months. They will resist freezing for weeks, followed by drying, without injury.

Propagative Organs.—Organs of another kind than oogonia and antheridia are developed on the mycelium. The function of these is chiefly for the immediate and rapid propagation of the numbers of the parasite. The organs are like the oogonia, either terminal or intercalary swellings of the hyphae, and at first do not differ materially from them before the defferentiation of the egg cell and antheridium. These organs are exactly alike in form but differ in the discharge of their functions and are termed respectively, conidia, resting conidia, and zoosporangia.

Conidia.— The conidia measure about the same as the oogonia and when fresh water is added to them they will germinate immediately after maturity, which is attained upon reaching their full size.

Resting Conidia.—These are conidia which do not germinate immediately and acquire a somewhat thicker wall than the conidia. They pass through a period of rest before germinating. They are identical in form and size with the conidia. They are capable of growing after being frozen, and after drying, and serve in this way much the same function that the oospores do in that they tide the fungus over quite long periods which are unfavorable for the growth of the plant.

In germination the conidium thrusts out, by an extension of its wall, at one or more points, a slender tube which elongates into a hypha exactly like those of the former mycelium. This enters a young seedling when favorably situated, and starts the disease again.

The conidia and zoospores are rarely developed so abundantly in this species as are the oogonia. In my cultures during January and February, 1894–5, the oogonia were far more abundant and no zoosporangia were observed. DeBary says that sometimes one may search for weeks and even months and not find zoosporangia. I have, therefore, not had as yet an opportunity of studying the formation of the zoospores from the zoosporangia and can not say whether or not they agree with those of *Artotrogus intermedius* (deBary), which will be described in the next paragraph. The following account is therefore abbreviated from published descriptions.[3] The zoosporangia are usually not to be differentiated from the conidia until the time for the development of the zoospores. They are either terminal or intercalary, and sometimes so much of the protoplasm migrates into them during development from the supporting hypha that this is emptied for a short distance near the point where the wall separates the zoosporangium from the contents of the hypha. They usually remain attached to the supporting hypha and at the time of maturity, if placed in fresh water containing oxygen, a short protuberance is developed on one side at nearly right angles to the supporting hypha, which grows to a very short tube of a varying length but always shorter than the diameter of the zoosporangium. Into this tube the protoplasm migrates and causes the end of the short tube to swell out into a rounded vesicle of about the same diameter as that of the zoosporangium, with a thin enclosing membrane. The protoplasm now breaks up into a number of kidney-shaped masses, with two lateral cilia according to most authors, although Hesse,[4] who first described the process in this species, says that the zoospores are oval and uniciliate. These swarm about in the water for a few minutes, come to rest, round off and germinate in the ordinary way for conidia by sending out a slender germ tube which when favorably situated will start the disease in fresh plants. It is probably by the development of these in wet soil during rain or at the time of watering the pots or soil in seed beds that the disease is spread so rapidly.

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[3] DeBary, Zur Kennt. d. Peronosporeen, Bot. Zeit. 39, 521, 1881, Beitr. z. Morph. u. Phys. d. Pilze, IV, 1881.

Schroeter, Pilze, in Engler u. Prantl, Naturl. Pflanzenfam. 1, 1 104.

The fungus is, however, capable of developing as a saprophyte on dead or partially decayed organic matter in the soil so that with one watering it may become well seated in nearly all parts of the bed. To show that it is also a saprophyte it is a very easy matter to start it in the laboratory on the leaves or stems of seedlings which have been previously killed by boiling.

This damping-off fungus was first described by Hesse in 1874 (l. c.) and named by him *Pythium debaryanum*. It was shown by him to be a parasite of seedlings, such as *Camelina sativa*, *Trifolium repens*, *Spergula arvensis*, *Panicum miliaceum* and *Zea mays*, while seedlings of *Solanum tuberosum*, *Linum usitatissimum*, *Papaver somniferum*, *Brassica napus*, *ornithopus sativus*, *Onobrychis*, *Pisum*, *Hordeum vulgare*, *Triticum vulgare* and *Avena sativa* were not attacked.

DeBary made a comprehensive study of the sexual stage.[5] *Pythium equiseti* Sadebeck, is in his opinion the same species. *P. equiseti* was first described by Sadebeck[6] in 1874 from prothallia of Equisetum arvense, and in farther studies[7] it was shown that not only did it occur in potatoes affected with *Phytophthora infestans*[8] but that healthy potatoes could be inoculated with it. *Pythium autumnale* Sadebeck which grew in young plants of *Equisetum palustre* and *E. limosum*, produces oospores which develop parthenogenetically. Fischer[9] places this in *P. debaryanum.* A plant found in *Lepidium sativum*, and in *Beta* and *Sinapis* by Lohde,[10] was described by him as *Lucidium pythioides* and from the description there is little doubt that it is the *Artotrogus debaryanus. L. circumdans* described by the same author in a fern prothallium[11] develops only in the margin of the same, producing short conidiophores and zoosporangia with 4-8 zoospores. Fischer[12] also includes this with *P. debaryanum* Hesse, as well as the *Saprolegnia schachtii*[13] described by Frank in the thallus of the liverworth *Pellia epiphylla.* Zoospores were not seen and oogonia only rarely, the plant being usually sterile.

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[4] Hesse, Pythium debaryanum, ein entophytischer schmarotzer, Halle, 1874.

[5] Beitr. z. Morph. u. Phys. d. Pilze, IV, 1881.

[6] Ueber einen der familie der Saprolegniaceen angehorigen Pilze in dem prothallien des Ackerschachtelhalmes. Sitzungsb. d. Bot. Ver. d. Prov. Brandenberg, 116-122, 1874.

[7] Neue Untersuchungen über Pythium equiseti. Sitsungsb. d. Gesells. naturf. Freunde z. Berlin, V, 21, 1875.

[8] Ueber Infectionen welche Pythium-Arten bei labenden Pflanzen hervorbringen. Beibl. z. Tageb. d. 49 Vers. deutscher naturf. u. Aertze, 100, 1876.

A number of these are probably rightly referred to *Artotrogus debaryanus* (Hesse.) Unfortunately these plants can not well be preserved for study in their several stages and in most of the cases probably no specimen of any stage has been preserved, so that it would be quite impossible at the present time at least to speak with any feeling of certainty on the proper disposition of these forms. There is need of a thorough and comprehensive study of the species of the genus, and considerable uncertainty will probably exist as to the proper disposition of some of the above species until they can again be found and critically studied.

The fungus has been several times reported in this country, and many notices of damping off have been made without, probably, any serious attempt to determine the species. T. W. Galloway from a careful study determined it from seedlings of *Gilia*, *Viscaria Lobelia*, etc., in the Botanic Garden of Harvard University. He did not, however, observe the zoospores. Humphey[14] also carefully determined the species, but does not describe the zoospores.

DAMPING OF PROTHALLIA.

Artotrogus intermedius (*de Bary*).

This species was first noticed in fern prothallia growing in the botanical conservatories of Cornell University in the month of

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[9] Rabenhorst's Krypt. Flora. Pilze, IV, 404, 1892.

[10] Ueber einige neue parasitische Pilze. Tagebl. d. 47 Vers. deutscher Naturf. u. Aertze, 203, 1874.

[11] Ueber einige neue parasitische Pilze. Tagebl. d. 47 Vers. deutscher Naturf. u. Aertze, 203, 1874.

[12] Rabenhorst's Krypt. Flora. Pilze, IV, 404, 1892, 4 Ibid.

[13] Notes on the fungus causing damping off, etc. Trans. Mass. Hort. Soc. I, 1891.

[14] 8th Ann. Rept. Mass. State Agr. Exp. Station, 220, 1890.

February, 1894. The affected prothallia were quite soft, limp, and darker in color than the healthy ones. Some were placed in water on a glass slip and kept in a moist chamber. The following day the fungus had grown out of the prothallial tissue and had extended a considerable distance over the slip. The mycelium is at first non setate and contains granular protoplasm which is present in minute irregular masses, having in the larger threads much the appearance of the protoplasm in some mucors, and in some cases well marked and strong currents of the protoplasm have been observed, which resemble the movement of the protoplasm in these plants.

The threads branch monopodially, the extent of the branching depending, to a certain extent, on the amount of the vegetive growth. The threads put out in the water from the prothallia may be quite long and possess primary and secondary branches before conidia are developed to any great extent. The conidia are developed at the ends of the main threads or their branches, the hypha swelling at the end into a round body several times the diameter of the thread itself. In other cases the thread may develop a conidium while it is still quite short and the growth of the thread in length practically cease. In other cases the conidia are developed at the ends of the primary or secondary branches as well as at the end of the main hypha. Where the conditions are not favorable for the rapid growth of the vegetative portion of the plant, sometimes the conidia are developed more profusely and rapidly so that they are many times produced in chains. Frequently these are in nearly

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Explanation of Plate 1. *Artotrogus debaryanus* (*Hesse.*)

Figs. 1, 2 and 3, different stages in fertilization; *a* antheridium, *oog.* oogonium, *e. c.* egg cell, *gon.* gonoplasm, *oosp.* oospore.

Figs. 4 and 5 intercalary oogonium with stalk antheridium (*s. a.*) and branch antheridium (*b. a.*) in 4 with gonoplasm separated from the periplasm, and in 5 fertilization complete.

Fig. 6 terminal oogonium with stalk and branch antheridium.

Figs. 7 and 8 different stages in development, and fertilization, of sexual organs; *b* in 7, oogonium before the formation of the egg cell.

Fig. 9 oogonium with stalk antheridium (*a*) which has fertilized the egg cell, and branch antheridium (*b*) from another hypha than that which bears the oogonium. In this branch antheridium the gonoplasm has separated, and the fertilization tube has formed, but fertilization took place from the stalk antheridium first and the wall of the oospore prevented the use of the gonoplasm from the branch antheridium.

All the figures drawn with aid of camera lucida and magnified fifty times more than the scale. Scale—1 millimeter.

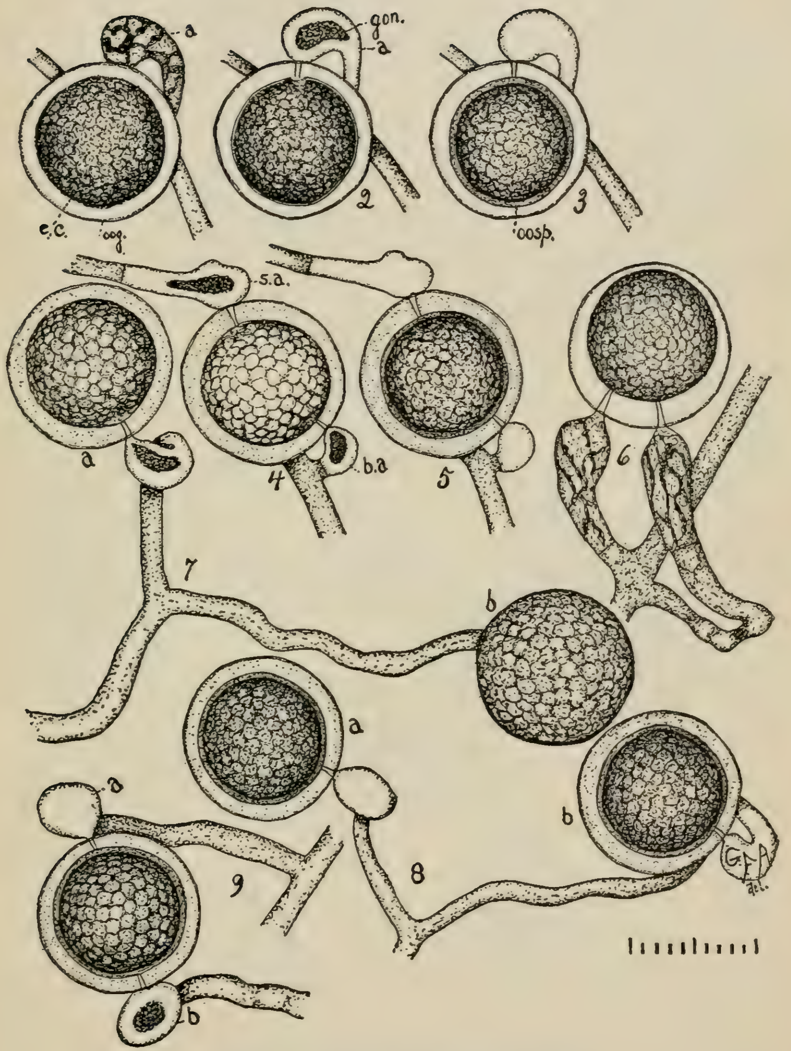

Plate I—. Artotrogus debaryanus (Hesse).

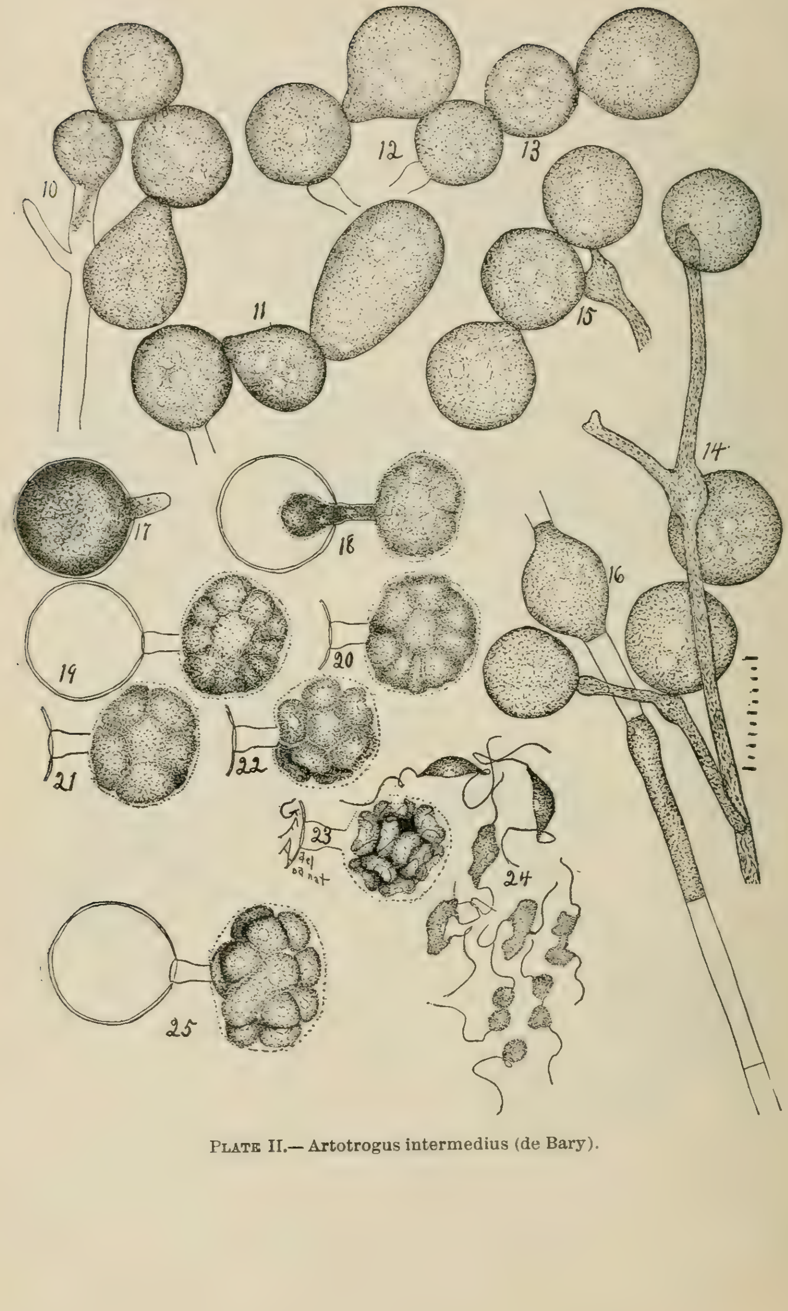

PLATE II.— Artotrogus intermedius (de Bary).

straight chains, or they may form a curve, or again a short and close spiral so that they are held close to the point of origin in a small head.

The conidium may be spherical or broadly apiculate at the proximal end or more minutely apiculate at the distal end. Sometimes there is no enlargement of the fruiting thread at the point of origin of the conidium, but very frequently, and in a majority of cases which I have observed where they are grown in water, there is an oval enlargement of the hypha with a minute apical sterigma which bears the conidium. Where there is quite rapid growth of the fungus the hypha grows onward pushing the recently developed conidium to one side, but not always freeing it, and soon bears another conidium in like manner. This continues so that several conidia may be borne at short intervals on the same branch, and the successive points of the origin of the conidia are not only marked by the attached conidia but by the oval enlargements on the branch. The appearance is thus, in many cases, very much like that of the conidiophores of *Phytophthora*, and de Bary has called attention to the same fact. Many of the conidia become free.

Early in April of the same year cultures were again started on glass slips in water. A preparation was started Tuesday afternoon, April 10th, at 3 p. m. At 6 p. m. considerable growth had taken place and several conidia were developed. At 9 p. m. another examination was made and quite a profuse growth was present and numerous conidia or zoosporangia.

At 9 a. m., April 11th, there were many free conidia and zoosporangia and the culture abounded in the form of fructification which so closely resembles *Phytophthora*. Fresh water was now added to the preparation, a cover glass placed upon it for the purpose of studying it with the high power of the microscope and for obtaining

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Explanation of Plate II. Artotrogus intermedius (de Bary).

Figs. 10, 11, 12, 13, conidia developed in chains.

Figs. 14 and 15, conidia borne in a manner resembling the conidial fructification in Phytophthora.

Figs. 17–23, different stages in the development of the zoospores.

Fig. 24, free zoospores with a cilium at each pointed end, passing into amœboid movement and becoming divided into oval unciliated zoospores.

Fig. 16, intercalary conidium.

All the figures from camera lucida drawings and magnified fifty times more than the scale. Scale 1 millimeter.

camera lucida drawings. After making several sketches of desired objects one zoosporangium was discovered emitting the protoplasmic vesicle preparatory to the differentiation of the zoospores. When the eye first fell upon it the object was in the phase represented by Fig. 18. Soon the protoplasm had all passed through the short tube and was collected in a rounded vesicle at the end. There was a slight differentiation of the protoplasm at the time of the passage, but it was little marked. The differentiation became more and more marked showing that the mass was dividing into ten or twelve polygonal bodies. The surface of the forming zoospore next the wall of the vesicle, or the periphery, is the longer, and at the middle of the outer surface of the object there soon appears a depression which gives each a curved appearance. This form becomes more and more marked and now movement begins, which first appears as a kneading of the entire mass, and as they become more and more sharply differentiated each young zoospore produces an oscillatory movement with its center nearly stationary, the movement of course much restricted by the surrounding vesicle. As they assume more distinctly the curved appearance there is developed from each end of the zoospore a cilium by the lashing of which the movement becomes more violent and results soon in the release of the swarmers when they suddenly dart away.

The movement is now a complex one. The oscillatory movement is more marked with a tendency in many cases to produce figure of 8 cycles, which is combined with a jerky progressive movement in the direction of the longitudinal axis. Frequently when they come in contact with some object larger in size, they simulate to some extent the movements of a paramæcium along some object in the water.

The form of the mature zoospore is broadly fusoid, inequilatera with pointed ends which terminate in a long cilium. After five to ten minutes the movement of the swarm spores becomes slower and finally it nearly ceases and the body undergoes plastic movements resembling somewhat that of an amoeba as represented in Fig. 24. At first this amoeboid movement is irregular but after a few minutes it assumes a definite character which tends to cut the organism into two parts. This progresses until complete fission results in the formation of two zoospores which are oval in form with the cilium attached directly at the smaller end.

This peculiarity in the development of the zoospores is one which has not heretofore been recorded except in a preliminary paper by the writer.[15] The species was at that time studied along with the seedling fungus, A. debaryanus (Hesse), and as this is reported as occurring also on fern prothallia (*Todea africana*) the species now under discussion was then supposed to be the same, and to this species it was doubtfully referred. But the development of the conidia is very different from that described for any other species of this genus resembling that of *Phytophthora* as stated above.

It can not therefore at the present time be said with certainty that the zoospore formation in *Artotrogus debaryanus* is the same as that found for *A. intermedius*, though what evidence we already have on the subject might be interpreted to support that view of the case.

Where the soil is kept very damp and the air of the house is quite humid the prothallia are apt to be overrun by certain algae which choke the prothallia, shut out the air and light, prevent their proper development and frequently cause them to be completely sterile. Many of the prothallia are thus killed, sometimes entire beds or pots of them. A very common alga which I have several times observed is a variety of *Hormiscia flaccida* (Kuetz.) Lagerh. Species of *Oscillatoria* are also frequently present and produce a like injury.

If the pots or vessels in which the prothallia are grown are rested on sphagnum, a layer of which can be placed in the bottom of the wardian case, and after the young prothallia have started, all of the watering be applied through this, the prothallia will do much better than if surface watering is practiced and far better than where the pots are rested in a vessel partly full of water. The air of the wardian case or of the house should not be kept too damp.

NOTE ON THE GENUS ARTOTROGUS.

Hesse, who first described *Artotrogus debaryanus*[16] (*Pythium debaryanum* Hesse) says, as stated above, that the zoospores are oval and provided with one cilium. *Pythium equiseti*[17] Sadebeck, which is generally considered to be the same plant, possesses two lateral cilia according to the descriptions, and de Bary only says that the zoospore formation takes place in the oft described way.[18] In *Artotrogus proliferus*[19] (de Bary), the author, was unable to determine whether the zoospores were unciliate or biciliate. In the vesicle they are figured as reniform, but the ultimate zoospores are described as oval, one end being narrower than the other. Double zoospores were also described which possess two light spots instead of one. These ultimately divided, but before division, according to the author, the double zoospore was like that of an organism controlled by two opposing wills. This was not the case with the biciliated zoospores observed by myself in *Artotrogus intermedius*, until amoeboid movement was beginning after a period of swarming, and when fission is about to take place. Possibly de Bary observed the "double" zoospores just at that time.

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[15] Preliminary note on the swarm spores of Pythium and Ceratiomyxa, *Bot. Gaz.* XIX, 375, 1894.

Pythium debaryanum, etc. Halle, 1874.

[17] Untersuchungen über Pythium equiseti, Cohn's Beitr. z. Biol. d. Pfl. III, 117.

In *Artotrogus pythiodes*[20] (R. et C.) the zoospores are described and figured as biciliate, one cilium attached at each pointed end of the zoospore exactly as I have found in the case of *A. intermedius*. But in *A. pythiodes* the authors say that the zoospores absorb the two cilia, round off and germinate, *i. e.*, they do not divide, if the observations are clear on this point. This species was found on leaves of *Wolffia mitchellii.*

Other species of the genus are as follows: *A. hydnosporus*[21] Mont. in potatoes and in dead seedling plants.[22] *A. ferax* (de Bary) in dead insects and in dead seedlings in water. *A. megalacanthus*[23] de Bary, in dead seedlings and parasitic in prothalia of *Todea africana.* *A. proliferus*[24] (de Bary) saprophytic on dead seedlings and insects in water; *A. vexans*[25] (de Bary) in dead seedlings and in diseased potatoes; *A. anguillulae aceti*[26] (Sadebeck), parasitic in *Anguillula aceti; A. sadebeckionus* (Wittmack) producing epidemics of diseases in lupines and peas. Several other species have been imperfectly described.

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[18] Zur Kenntniss der Peronosporeen, Bot. Zeit. XXXIX, 524, 1881.

[19] Pythium proliferum de Bary, Pringsh. Jahrb. f. wiss. Bot. II, 182, 1860.

[20] Roze et Cornu, sur deuz nouveaux types generiques pour les Familles des Saproleguees et dess Peronosporees, Ann. de sci. nat. Bot. ser. 5, II, 72, 1869.

[21] Montagne, syolloge, etc., p. 304, 1845.

[22] Bot. Zeit. XXXIX, 562, 1881.

[23] Beitr. z. Morph. u. Phys. d. Pilze. IV., 19, 1881; Bot. Zeit. XXXIX, 578, 1881.

[24] Pringsh. Jahrb. f. wiss. Bot. II, 182, 1860.

[25] Jour. Bot. V, 119, 1876.

[26] Bot. Centralbla, XXXIX, 318, 1887.

A POTTING BED FUNGUS NEW TO AMERICA.

Completoria Complens Lohde.

This is an organism which is parasitic upon fern prothallia grown in forcing houses. It has been known in Europe for several years, but was first found in this country during the winter of 1893-4, in the botanical conservatories of Cornell University, while studying the rotting of prothallia induced by *Artorogus intermedius* (de Bary), described in a former paragraph of this paper. Ultimately the prothallia decay, but the first signs of disease when caused by this parasite alone is the appearance of a yellow or yellowish brown color imparted by the prothallia as they lie on the soil of the pot or bed. The prothallia are so small that usually the color appears to reside in the entire prothallium when seen by the unaided eye. When examined by the aid of a microscope, however, unless the prothallium is in the last stages of the disease, the decay will be seen to be confined to "spots."

These spots vary in color from a yellowish green to yellowish brown, deep brown and finally blackish, dependent on the phase of the injury to the cell and its contents. At first the injury is confined to single cells, either near together or far isolated, on the margin of the prothallium or at any point over its surface.

When the trouble is well advanced and there are numerous centers of the disease, as frequently happens, the prothallium will present a checkered or mosaic appearance, the different pieces of the mosaic being colored with the various shades of color detailed above. It also presents at this time quite a ragged appearance, because many of the cells are dead and the disintegration of their contents makes holes in the plant and rifts in its edges. A short note on the occurrence of this fungus in the United States was published by the writer in the *Botanical Gazette* for November, 1894. It is a very interesting fungus from its very simple structure, its peculiar form, mode of development, and as a plant parasite, from its being a member of the *Entomophthoreae*, which are almost entirely parasites of insects.

The vegetative body of the fungus is a more or less compact, grape like, botryose cluster of oval or curved hyphal branches originating from a common center, and presenting on the surface a series of convolutions formed by the external hyphal branches lying close together over the surface. This vegetative body lies within a single cell of the prothallium, sometimes completely filling even quite large cells, while at other times the body may be smaller especially in smaller cells of the prothallium, where it sometimes consists of only a few hyphal branches closely curved upon their parent cells. These hyphal branches vary from 7μ to 15μ in diameter or may even be of a greater diameter, and are one and one-half to two times longer. When the plant body in a single cell becomes mature it may spread to the surrounding cells by certain of the external hyphal branches putting out a slender germ tube which pierces the adjacent intervening wall. This is done by the tube of the hypha excreting a substance which dissolves the cellulose of the wall making a small minute pore and at the same time turning the adjacent portions of the wall brown in color. The wall of the slender thread which squeezes its way through this opening is also colored brown, and this color is frequently extended to the slender portion of the thread or tube, in which the protoplasm passes or migrates to the center of the cell as shown in Fig. 44.

When it has reached the center of the cell lumen the free end enlarges and forms a rotund body which finally becomes oval. At this time it is about 15μ to 25μ in diameter, with quite coarsely granular protoplasm and with one or more large vacuoles. By this time also all of the protoplasm from the original cell has moved into this oval body in the center of the cell, leaving behind only the wall of the slender tube by which it gained entrance and which is still connected with the wall of the living organism. This old wall, as well as the wall of the prothallial cell where the organism entered, becomes brown in color soon after the protoplasm has passed through into the center of the cell of the host. From the free and smaller end of this oval cell a short protuberance grows curving to one side usually rather close to the side of the parent cell. Sometimes this branches quite soon in a dichotomous manner and the two short cells curve in opposite directions. If dichotomy does not occur at the beginning of the protuberance another branch arises soon from the original cell or from the branch. These protuberances become enlarged at a very short distance from their origin forming oval cells. These in like manner produce short branches, and the process continues until a botryose or convoluted mass of cells is developed which eventually fills the cell of the prothallium, and the elements of the botryoid body become angular from mutual pressure. The wall now becomes brown in color and the glomerule appears to be mature.

In this condition if these hyphal masses are teased out from the cell of the prothallium and kept on a glass slip in a small amount of moisture germination soon takes place. Hyphal masses so teased out from the prothallium and placed under the above conditions at 5 p. m. on February 22, 1894, and kept at the ordinary room temperature during the night, the temperature falling somewhat below that of the day (the temperature was 70° to 80° Fahr., up to midnight and fell 30 toward morning and rose to 66 at 9 a. m.). At 9 a. m. February 23d, the preparations were examined and the mature hyphal masses were germinating. In some cases the germ tubes were 500μ to 700μ long and all the protoplasm had moved out in the distal half of the tube (Fig. 42). In germination under such circumstances a protuberance arises from one of the individual cells of the glomerule and extends soon into a tube the diameter of which is about 10μ. As the tube extends in length the protoplasm gradually disappears from the parent cell and passes into the tube. As the tube continues to elongate the protoplasm continues in the distal portion and the older portion of the tube becomes empty, nothing remaining but the wall. There appears to be a wall at the junction of the tube with the parent cell, if so, it is formed after the protoplasm has passed into the tube. When the tube has become considerably elongated so that there is an empty portion from 200μ to 500μ in length there appear what seem to be transverse septa, or it may be the remains of a portion of the protoplasm situated in a thin transverse sheet in the tube. These occur so regularly and at about 30μ to 40μ distant that the resemblance to septa is very striking if they are not really septa. If they are septa they are formed only after the protopalsm has passed these points. It may be that the growth of the tube was arrested for a certain length of time and the walls were formed while it was in this quiescent condition, or the growth of the tube may be naturally periodic. The protoplasm is coarsely granular, presenting here and there rather faint vacuoles, but there are, so far as examined, no septa separating the protoplasm into distinct portions. The course of the tube is slightly sinuous, and also in an ascending position as the glomerule lay on the glass slip. Perhaps this was for the purpose of emerging from the water. After an examination the cultures were returned to the moist chamber.

While the fungus is progressing through a prothallium when one of these spore balls becomes mature, some of the cells lying adjacent to healthy cells of the prothallium germinate and grow directly into the new cell host. In doing so the germ tube is very much smaller since less energy is expended in making the perforation through the wall. After emerging from the wall in the new host cell the tube does not enlarge to the size of the tube when germination takes place in water on the glass slip, but remains about the same size as that of the perforation in the wall, until it reaches the center of the cell lumem where it enlarges into a rotund body as described above. Here it soon grows into the botryoid hyphal mass again. Other cells may germinate and course for a considerable distance over the surface of the prothallium and enter new host cells quite distant from the hyphal mass, but this has not been observed. In some cases more than one cell lying quite close to a new host cell will germinate and grow into the same. From the observations thus far made I should judge this to be quite common but not general.

The first ovoid portion of the mycelium in the center of the cell of the host is considerably larger than the curved branch which develops at its apex and frequently larger than any which follow. The more slender form of these branches and the close apposition of the branches to the primary enlarged ovoid portion suggests a striking resemblance to an oogonium and antheridium. Thus far I have not seen any conclusive evidence that these organs are present. However, frequently the conditions are favorable for the de-

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Explanation of Plate III. Completoria complens Lohde.

Figs. 26-30, different plants with mature resting spores, showing the variation in number developed in a single plant; the resting spores surrounded by the empty peripheral cells of the plant, which may have developed conidia, or some of them entered adjacent cells of the prothallium, or possibly some of them fed the developing resting spores.

Figs. 31, 32, younger stages in the development of the resting spores.

Fig 34, plant developing resting spores at the center and a conidium from one of the peripheral cells.

Fig. 35, conidium germinating; 36, 37 and 39 germinating conidia with the germinal vesicles or proembryos developed from each one.

Fig. 40, germinal vesicle or proembryo developing the minute entrance tube which pierces the wall of the cell of the prothallium; 38, showing the entrance tube complete and the protoplasm having migrated to the center of the cell where the rotund body is formed; 41, branching of young plant in cell of host.

Drawn with aid of camera lucida and magnified 30 times more than the scale. Scale 1 millimeter.

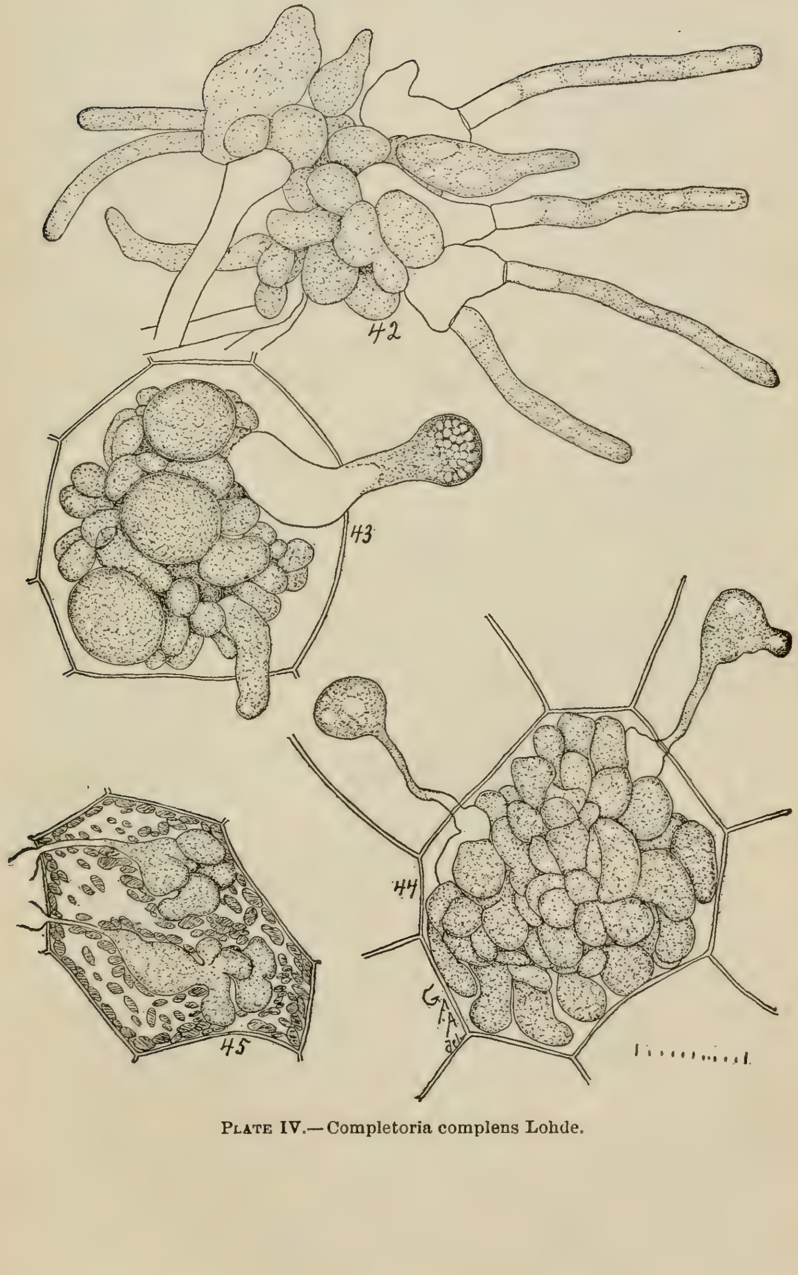

Plate IV.—Completoria complens Lohde.

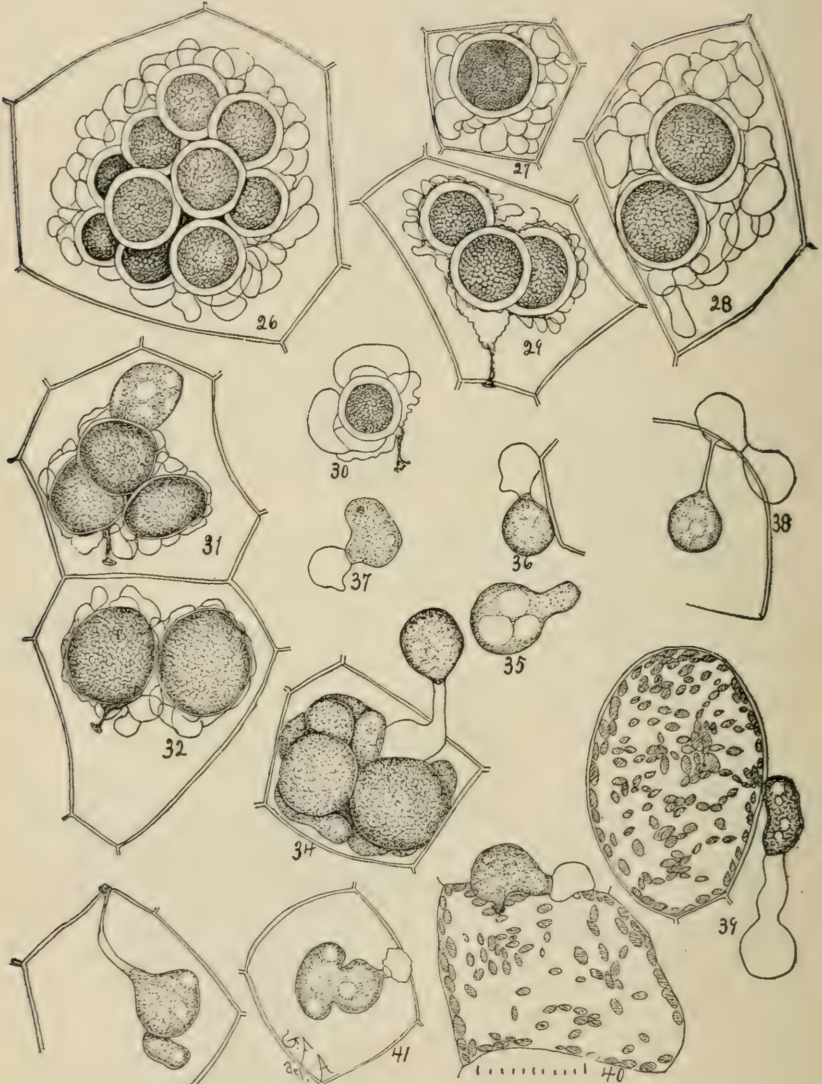

PLATE III.— Completoria complens Lohde.

velopment of another form than the purely vegetative portion of the plant, and either simple resting spores are developed, or if sexual organs are present, then oospores. The number of resting spores varies from one to ten or even twenty in large prothallial cells where the botryoid fungus is well developed. The resting spores occupy the central portion of the mass and are surrounded by the smaller and terminal cells of the plant which now are empty. The resting spores are rounded, sometimes oval in form, and when mature are bounded by a very thick wall consisting of three coats, which are smooth, but sometimes appear roughened by the closely cohering cell walls of the collapsed surrounding terminal portions of the botryose mycelium. The portions which become resting cells are always the larger and central portions. They are much larger at the time of the formation of the resting spores than when the fungus is in the vegetative stage, and since at first there appear to be no cell walls intervening it would seem that their increase in size came chiefly from the outer and smaller cells giving up to them their protoplasmic contents rather than that the additional nutriment came from the cell of the host which by this time is nearly exhausted. However, this point was not determined. The wall of the young resting spore is at first very thin and the protoplasm finely granular. The mature resting spore presents a very coarsely granular protoplasm the granules rounded in form and closely packed together.

Propagation also takes place by the production of non-motile Conidia from monosporous sporangia.

The conidia are oval or broadly obovate, colorless cells, with a thin wall and measure from 15μ to 25μ in diameter. In germinating, unless they are lying entirely immersed in water or in an

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Explanation of Plate IV. Completoria complens Lohde.

Fig. 42, botryose cluster of plant body after being placed in water, the peripheral cells germinating and forming long tubes.

Fig. 43, plant body, some of the central cells forming resting spores, and some of the peripheral ones developing conidia.

Fig. 44, plant body in one cell of the host, the peripheral cells developing tubes which penetrate adjacent cells of the prothallium.

Fig. 45, two young plants in one cell of the host having entered from an adjacent cell, early stages in the branching and development of the botryose plant body are shown.

All figures drawn with aid of the camera lucida and magnified 30 times more than the scale. Scale, 1 millimeter.

abundance of a water which may be on the surface of the prothallium or on the soil, they do not form a mycelial tube directly. A very short tube is formed and into this the protoplasm migrates and causes the end of the short tube to swell out into an oval or oblong vesicle or the vesicle may be separated from the conidium by a constriction. This phase reminds one of the formation of the zoospore vesicle in the species of *Artotrogus*. But the formation of this tube and of the vesicle does not take place so rapidly as in *Artotrogus*, and the form of the vesicle is quite different and varies considerably in form as well as in size, but the most marked difference is that there is a firmer covering which appears to be in the nature of a well-defined wall around the protoplasmic vesicle, while in *Artotrogus* there is only a protoplasmic membrane. Here the analogy ceases for zoospores are not formed. This cell is a germinal vesicle or proembryo, and from this proembryo arises the slender tube which pierces the cell of the prothallium and permits the parasite to enter. If the conidia are lying in an abundance of water they will germinate and produce a tube five to ten times the length of the diameter of the conidium. This I have several times observed, but in no such case have I observed the germ tube to enter a cell of the prothallium. Leitgeb states that in such cases which came under his observation the conidium only developed a short tube and then soon died.

The conidia possess a prominent apiculus which in development is directed toward and rests partly in the stalk of the sporangium. The sporangium develops from some of the superficial cells of the botryose body, but so far as I have examined from cells which are larger than the usual external cells. The cell begins growth in an upright position or away from the moisture and appears very much like an ordinary vegetative thread which is produced when the plant is immersed in water except that it is greater in diameter. When 60μ to 80μ in length the end becomes enlarged and the protoplasm collects into the forming sporangium. While the sporangium is forming the protoplasm is more coarsely granular at the base, while at the terminal portion it is more hyaline, giving the appearance of quite large and rather numerous vacuoles. When the spore is mature it is ejected with considerable force in much the same manner as the spores of the Entomophthoræ.

The aerial development of the sporangia instead of aquatic is in correspondence with the nonciliated condition of the conidia. One case which came under my observation shows clearly the necessity for the aerial development of the sporangia in the formation of the conidia in this plant. In mounting an affected prothallium in water for examination I discovered a partly formed sporangium which projected out into the cavity of an old and emptied ruptured cell. In the growing condition of the prothallia in this case they were somewhat crowded so that they stood more or less erect. The sporangium then in growing also in an erect position away from the moisture would be directed into the empty cell above. Placing this prothallium in a horizontal position on the glass slip in a small quantity of water would immerse the sporangium in the water, or partly so. All of the water was then drawn off except just a sufficient amount to prevent the prothallium and fungus from drying and the preparation was placed in a moist chamber in order that from time to time it might be examined to watch the development of the sporangium. This stage of the sporangium is represented in Fig. 43. No farther development of this sporangium took place. But just at the base of the stalk another one began to be thrown up in a position perpendicular to this prostrate one. As the new one increased in height the old one gradually lost the protoplasm both from the forming sporangium and the stalk. In the course of four to five hours the sporangium was mature and the conidium ejected, when the sporangium and stalk collapsed and remained as a flabby membrane attached to the wall of the old stalk and sporangium which was still in the water and which still remained intact.

The conidium is capable of germinating immediately when there is sufficient moisture and the behavior seems to be manifested in three different ways according to the amount of moisture, or in some cases perhaps according to the proximity of the host. If the spore is entirely immersed in water a long slender germ tube is put forth similar to the tube which is emitted from the terminal cells of the botryose body of a vegetatively mature plant. Where less water is present the conidium germinates by developing a germinal vesicle, or proembryo as described above.

From the inner face, the one lying next the prothallium cell, of the broader end of the proembryo, a minute tube is thrust out which pierces the cell wall of the host and grows out to the center of the cell lumen where in the ordinary way it enlarges into the first ovoid body of the new plant (Figs. 38, 40). In other cases probably, where there is still a less quantity of moisture, the tube from the germinating spore is directed upward or away from the host and becomes a sporangium with a very short stalk or only the short narrowed end of the sporangium which serves as a stalk. Before this conidium is ejected from this secondary sporangium if it be immersed in water, the protoplasm will grow out into a long slender germ tube. If it were only partially immersed it might as in the case of the primary sporangium noted develop a new sporangium. In the case of the primary sporangium which was immersed in water and which developed a new sporangium at the base of the old one, as described above, the base of the stalk was not entirely immersed.

As stated above the primary sporangia in the cases observed developed from some of the larger of the external cells of the cluster. In one case this took place while the inner cells were developing resting spores (Fig. 34). It may be possible that the sporangia are always developed from somewhat larger and richer cells of the periphery but more likely others of the cells can develop sporangia when the conditions of the environment, which have not all been determined, are such as to produce this tendency to fruit in the organism.

I have found the fungus in the prothallia of *Aspidium* (*Cyrtomium*) *falcatum*, *Pteris argyria* and *Pt. cretica*.

It was first described by Lohde[27] and was later more thoroughly studied by Leitgeb[28] who grew it in a large number of fern prothallia.

A NEW CUTTING BED FUNGUS.

Volutella leucotricha Atkinson.

April 10th (1894) two cuttings, in the botanical conservatory, of carnations which were damping off were called to my attention. These were placed in a moist chamber expecting to obtain the sterile fugus or an *Artotrogus*. Two days later, 12th, the stems were well covered with a fungus which formed elevated stromata, whitish in color or with a slight tinge of flesh color. With a hand glass the stroma was seen to be surrounded by several setae, which, however, did not present at the time a dark color as is the case with the common carnation anthracnose, *Volutella dianthi* (Hals.). At the time it was supposed that this lack of color in the setae might be due to the growth. Sections of the stromata showed the structure of a Volutella, but the conidia were considerably smaller than those of *V. dianthi* and the setae were quite different in form as well as in color. They taper but little toward the free ends, are quite blunt at the ends and usually more times septate.

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[27] Ueber einige neue parasitische Pilze. Tagebl. d. 47 Vers. deutscher Naturf. u. Aertze, 203, 1874.

[28] Completoria complens Lohde, ein in Farnprothallien schmarotzender Pilz. Sitzungsb. d. math. naturw. Klasse d. Akad. d. Wiss. LXXXIV, I, 288, 1881.

At my request Mr. R. H. Pettit, a student in my laboratory, made a separation of the fungus for me by the agarplate method. The first trial was successful and in a few days the colonies of the *Volutella* were visible to the unaided eye, the conidia having been kept watch of during the stage of germination and the formation of the colonies. The growth of the colonies is quite different from that of the *V. dianthi* as well as the development of the fruiting hyphae, and there was no longer any doubt that it was a different species from the *V. dianthi*, and the name *V. leucotricha* is here proposed for it.

Pure cultures were then started on bean and vetch stems and in a few days the characteristic stroma with the setae were developed in profusion on the surface of the stems. With the conidia from one of these cultures pure dilution cultures were made on April 20th. Instead of pouring a few drops of the first dilution into the second and from this into the third as I usually do with fungi having large conidia, the second and third dilutions were made by transferring with a double and twisted platinum needle. Plate No. 1 and 2 were sufficiently separated for the study of colony characteristics and for photographing natural size. The colonies grow rather slowly and the plate No. 2 was ready for photographing on the 25th, and No. 3 on the 27th. In No. 2 the colonies were quite numerous and consequently rather small, from 4–6 mm. in diameter, while those in plate No. 3 where there were only 6 colonies were on the 27th 10 mm. in diameter. The colony steadily develops a thin and nearly circular weft marked by numerous fine radiating lines which because of the exceeding thinness of the weft are visible over the entire colony as it ages. There are quite regularly more dense radiating lines caused by the overlaping of certain radiating areas, and the margin shows a tendency to form roundish angles. The growth is quite sensitive to periodic changes in temperature which occur between night and day, as shown by the several concentric lines which are quite pronounced on the colony. At the center of the colony there is developed quite a compact stroma which is very much like that on a more solid substratum, like the stems of the vetch or bean. This stroma may be quite extensive and irregular in outline with a few outlying smaller and scattered ones, or there may be quite a large number of them at the center of the colony, the larger ones of course nearer the center and the smaller ones at the periphery. These individual stromata are so far like those developed in solid substrata, either in nature or culture tubes, that they are margined with the characteristic satae. A photograph of several of these growing in the agar in a Petrie dish is shown in Fig. 52, plate VI, left upper corner. The photograph was taken from directly above and is magnified about 60 diameters.

In a few days after the appearance of the colonies the basidia begin to develop. Some of them and probably the first ones are prostrate and wholly or partly immersed in the agar. They may be simple, or branched, when the branches may be opposite, or irregular, and in some cases the branches are assurgent, when most of them are thrown to one side. There is a strong tendency for the threads of the mycelium to assume a moniliform appearance by the swelling of the short cells thus producing a strong constriction at the septa. This tendency to a swelling of the cells of the mycelium is also shown to some extent in the basidia. Quite early many of the fruiting threads become erect and branch several times, the ultimate branches forming the basidia. The branches and the basidia are frequently opposite or whorled and when standing alone simulate very well the conidia fructification of a *Verticillium*. For some time the conidia are held in chains as they are developed successively on the same basidium. When moisture is sufficient, and this is usually the case in the Petrie dish, the capillarity of the film surrounding the conidia pulls them from the concatenate position and they are gathered into a globular head appearing as if they were developed in the form of a *Mucor*. Very soon at the center of the colony by the development of numerous fertile hyphae very closely, a true stroma is formed, and the conidia are held by capilliarity in great masses upon the summit of the stroma.

After 24th a cell culture was prepared in a drop of nutrient agar at 5 p. m. On the following day the conidia were germinating and a group of them was photographed (46, Plate V, upper left corner). The spores here at this time were 4–5μ in diameter. The germ

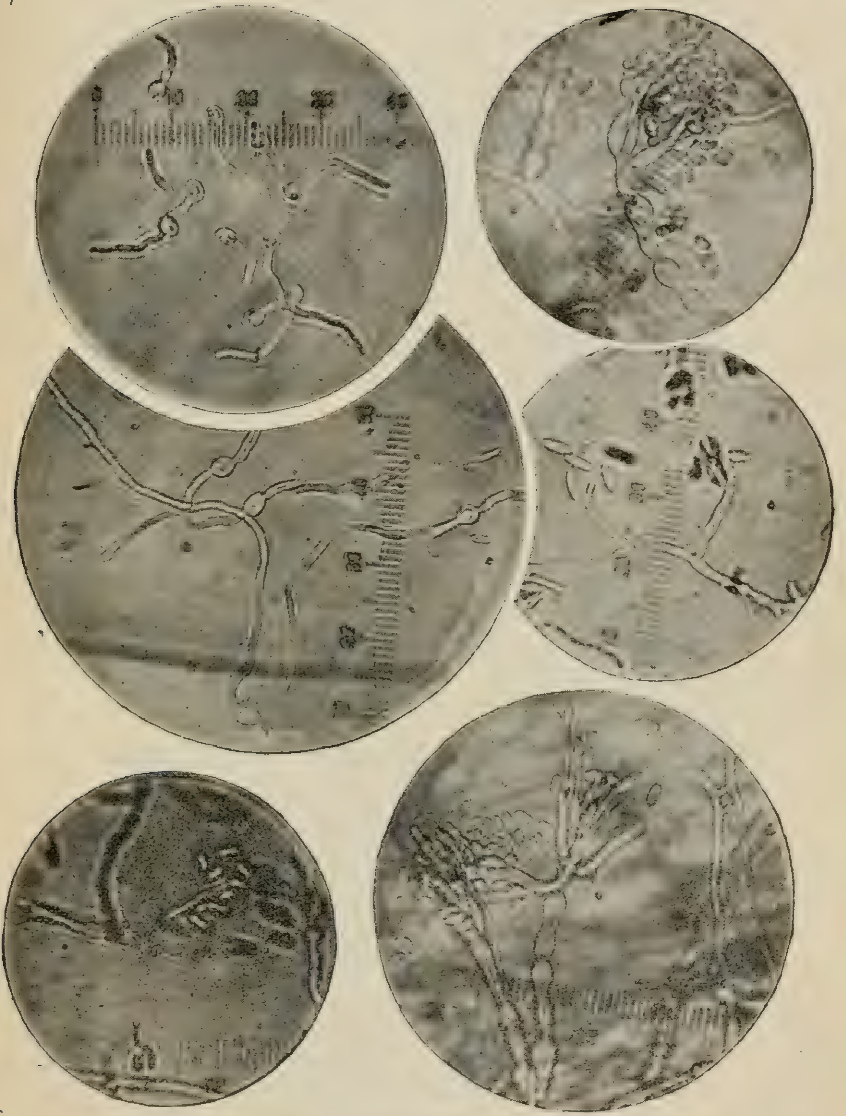


PLATE V.— Volutella leucotricha Atkinson.

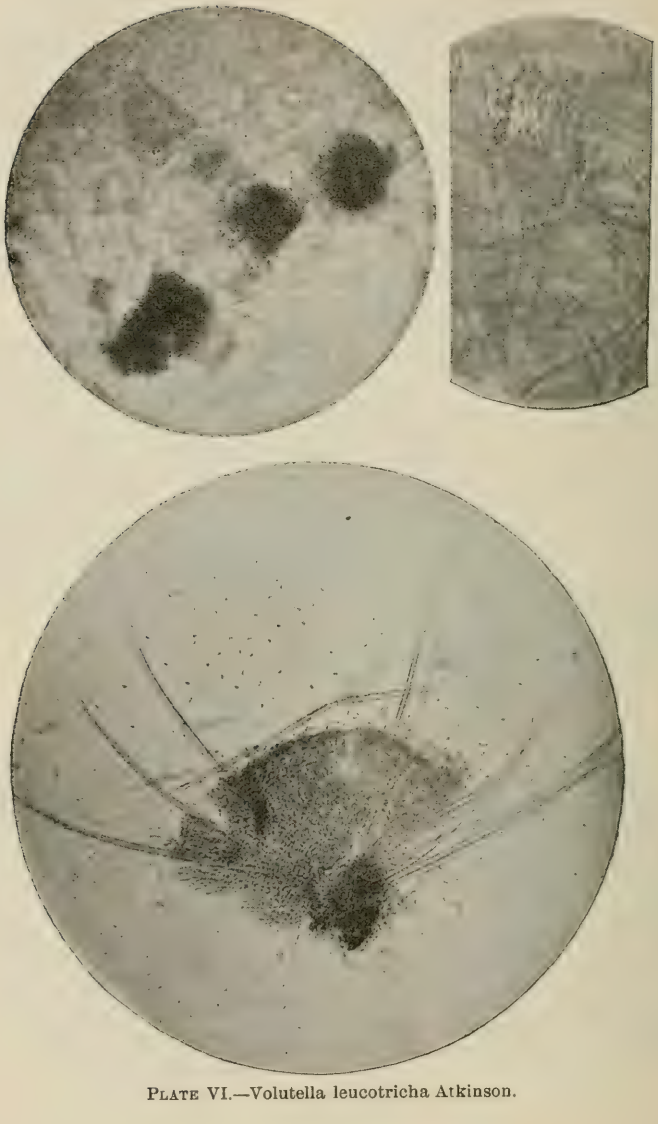


Plate VI.—Volutella leucotricha Atkinson.

tubes are quite sinuous, and at this age (seventeen hours from time of sowing) were 15μ to 25μ long, and about 2μ in diameter. In the germinating spores are a few, 3 to 5, small and very strongly refrigerent granules in the hyaline and homogenous protoplasm, and are quite well shown in the photomicrograph. On the following day when the culture was forty hours old another photograph was taken (fig. 47). By this time many of the conidia showed the development of three tubes, and the tubes were now quite long. In some cases the hyphae coming in contact, anastomose, one of these conditions being shown in the photomicrograph. One day later several of the conidia showed still other tubes, so that in time two to several tubes may arise from a single conidium. The anastomosing in some cases is quite common. In this cell culture, where the layer of nutrient agar was quite thin and the conidia numerous, fruiting did not take place very abundantly. In many cases the basidia are directly connected with the conidium, and in other and a majority of cases the basidia are developed from the hyphae at a variable distance from the conidium. The basidia under these circumstances are usually simple, terete and at the apex bear several conidia, which, because of the rather large per cent. of water in the medium, soon free themselves from the point of their origin and rest at one side. In a few cases the basidium is branched, or the fruiting hypha may bear lateral or opposite branches, and the terminal portion act as a basidium also. In this cell culture there was not the tendency for either the mycelium or the basidia to become swollen or enlarged. Two photo-micrographs were taken of the conidium production in the cell culture, one showing the development of a basidium directly from the conidium (50 lower left) and one with two basidia near each other on a single thread of the mycelium (48 middle right).

In order to study the separate conidiophores, or fruiting hyphae, recourse was had to the dilution culture, No. 1, in the Petrie dish. The conidia being so numerous in this dilution, caused the development of numerous colonies in quite close proximity, and the fruiting was necessarily more scanty and a less tendency to the development of the stroma so characteristic of the fungus on solid substrata, or in the agar where they were not so crowded. There were, therefore, many scattering and independent fruiting hyphae or conidiophores. By placing a thin cover glass over portions of the plate these erect conidiophores were bent in a prostrate position, and the amount of moisture was sufficient to displace the greater amount of air so that the medium between the glass and the agar was nearly of the same density as the agar itself, and quite satisfactory photographs could be obtained when the subadjacent growth of mycelium was not too dense to interfere with the entrance of light, or to produce a hopeless confusion of threads which were not desired. Figs. 49, 51 and 54 represent some of the conditions of the conidiophores in this culture, which have been referred to above. (Figs. 46–51 and 54 were photographed at an amplification of about 600 diameters.)

A portion of one of the fruiting stools which was teased out from a culture on vetch stems was photographed with an amplification of 100 diameters and is shown in Fig. 53, Plate VI, lower figure. The preparation was mounted in water and the conidia which were so numerous that they would have clouded the preparation were mostly washed out. Quite a number, however, remained in the preparation, and show as minute oblong dark spots over the field of the photomiorograph. The fruiting stool is composed of numerous branched sporophores closely compacted together.

CANKER IN CUCUMBERS.

What is sometimes called canker in cucumbers has occurred during the two past winters in the horticultural houses of Cornell University. The appearance is that of a large and deep ulcer in the stem at the surface of the ground. It occurs on plants of considerable size, on stems from 5 cm. to 1 cm. or more in diameter, the vines of which are several meters long. The ulcer has a dull brown color, the color of the external portion depending to some extent on the amount of soil which becomes worked into it. The tissues for some depth are soft and more or less putrid, dependent on the stage of the disease. It may advance so far as to cause the stem to rot off entirely, when, of course, the plant dies. In other cases the plant may not be ultimately killed but the ulcer has affected so deeply the vascular tissues as to interfere greatly with certain physiological functions of the plant. As the disease becomes serious the plants take on a sickly yellowish green color and become more or less limp. It soon runs its course, ending in death. During the month of December, 1894, sections of a diseased stem were placed in water and kept as described above for the seedling fungus, and in twenty-four hours a profuse growth of an *Artotrogus*, supposed to be the common *A. debaryanus* was developed. The species was at that time not accurately determined, and at the present writing there is none of the disease in the houses. The trouble is invited by keeping the soil around the stems in a too wet condition, just such conditions as favor the development of the seedling fungus. It is quite possible that another fungus, to be described in a later paragraph, may also have something to do with the etiology of the trouble.

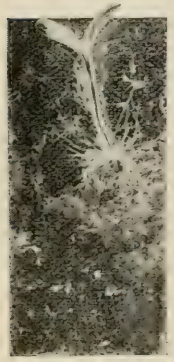
DAMPING OFF BY A STERILE FUNGUS.

Much of the trouble in the nature of damping off both in the forcing house and in the fields is caused by a fungus which has been under study at several different times during the last three years, but up to the present time has refused all the encouragement which it has been possible from present experience to offer it, with the hope of inducing it to develop some characteristic fruiting organs in order that its real nature and affinities might thus be made known. There are quite characteristic features of the mycelium and of certain sclerotoid bodies developed on the mycelium, and which, with a little care, serve to distinguish it from other known fungi.

I first observed it while studying the diseases of the cotton plant. (See Bull. Ala. Agr. Exp. Station, Dec. 1892.) In the cotton-growing States it is a very frequent parasite on young cotton plants, and produces a very large percentage, so far as my observation has gone, of what is known as " sore shin " in that section. The trouble is caused by the fungus growing first in the superficial tissues of the stem near the ground and disintegrating them before it passes to the deeper tissues; in other words the fungus never seems to penetrate far in the living tissues, but " kills as it goes," and the tissues become brown, depressed and present the appearance of the plant having a deep and ugly ulcer at the surface of the ground. The fungus does not spread into the tissues either above or below the ulcer to any extent, but literally eats away at that point until it has severed the stem at the affected place or the plant has recovered from its effects. The plants do not seem to suffer seriously from the disease until the woody portion containing the vascular bundles is nearly or quite eaten away.

In the latter case all communication between the root and the aerial portion of the plant is cut off, and, of course, the plant withers and dies. But frequently the stem may be eaten off so far that the plant has not sufficient strength in the remaining tissue at that point to support it and it will fall over, and, perhaps, if the disease does not progress any farther, it may remain fresh and green for weeks, but it is rare that after this stage the plant recovers sufficient strength at that point to erect itself again. Frequently, however, when the stem is nearly eaten off, the disease may be arrested, and the plant completely recover from the effects.

During the winter of 1894–5, some bean plants in the horticultural forcing houses of Cornell University were affected by this disease and quite a number of them presented brown and quite deep ulcers on the stems at the surface of the ground. A few of the plants went so far as not to be able to stand. Some of the worst ones were pulled up, but others which were quite badly diseased remained in the bed and all gradually recovered completely. The plants were six to ten inches in height when the trouble was called to my attention. When the plants attain this size the disease cannot make much headway, but even very young plants will frequently recover from the effects.



55.—Sterile fungus grown on slide from seedling of Centaurea candidissima.

It is more serious when it attacks smaller seedlings, as radishes, lettuce, etc. Egg plants and cabbages as well as others are known to be affected. Both the plants in seed beds in the forcing houses have been seriously affected by this fungus. Lettuce is frequently eaten off at the surface of the ground and the plants supported by others near may remain erect and fresh for several days. Gradually, however, if not quickly, they wither and fall when the fungus grows in the tissues farther as a saprophyte. If such plants be placed in a moist chamber, it is not necessary to place them in water; in a day or two there will be developed on the surrounding moist paper on which it is well to place the plants, a profuse growth of mycelium composed of whitish threads. To be sure that these threads are those of this fungus and not those of some mucor it will be necessary to have recourse to the microscope. The most characteristic peculiarity of the threads of the mycelium is to be found in connection with the branching. The freshly developed threads branch freely but not profusely; they are colorless, composed of elongated cells 9μ–11μ in diameter and 100μ–200μ in length. The protoplasm is finely granular and contains numerous small rounded vacuoles. The branches extend to an angle usually of between 30 and 60 degrees from the main hypha and very near the point of attachment are a little curved toward the point of growth of the same. At the point of attachment with the parent hypha the branch is considerably smaller than either the diameter of the parent hypha or the main part of the branch, and the septum separating the protoplasm of the greater part of the branch from that of the parent hypha is situated some distance from the latter, usually 15μ – 20μ from the main thread. This portion of the branch then, the contents of which are continuous with those of the parent thread, is clavate in form. Species of *Botrytis* will occasionally be developed in diseased tissue of this kind, and sometimes develop phenomena of damping off similar to that produced by this fungus, though much more rarely, and the mycelium in its early stages can not, so far as I am able to tell, be differentiated from this sterile fungus. But if a culture of the mycelium be made, in the course of a few days or in a week, if the mycelium be that of *Botrytis* the conidial stage or the clasping organs will be developed. But if it be that of this sterile fungus, no such conidial stage will be developed.

Pure cultures of the fungus have been obtained at two different times. In the summer of 1892, from young cotton plants, and again in February, 1895, from young lettuce plants which were damping off. It can quite easily be obtained in pure culture by transferring some of the mycelium grown in the air of a moist chamber to some acidulated culture media. A very good medium is made by placing cuttings of bean stems, 7 to 8 centimeters long, in a culture tube and adding to this about 8 cc. of water and 1 drop of concentrated lactic acid. Several of these culture tubes should be prepared, and then sterilized in steam for two hours per day for three or four days in succession. The bean stems should project 2 to 4 centimeters above the liquid, and to the ends of these the mycelium can be transferred with a flamed platinum needle. Several transfers should be made, and from portions of the mycelium which have been previously examined, to be certain that mucors or other fungi are not present. Out of several transfers, if the growth in the moist chamber has been made with caution, a few pure cultures are quite likely to result.

Bacteria will be shut out by the acid in the medium, and if the culture is free from other fungi in a few days the mycelium will be visible as a silky white growth which spreads over the surface of the bean stems, growing downward over them and also outward onto the surface of the glass tube. This growth continues to advance for several days with quite an even advance edge to the weft. In the course of four or five days, or one week, from the time that the mycelium is visible to the eye in the culture tube, there will appear first on the stems at certain points, and later on the surface of the glass tube, minute white powdery looking tufts on the mycelium. These are made up of closely and profusely branched threads, the branching sometimes presenting numerous and quite regular dichotomies, at other times quite irregular, and the terminal branches profusely lobed, the lobes standing in all directions and considerably more slender than the threads of the mycelium, and from 10μ to 20μ or more in length, occupying the distal portion of the branch for a distance from 20μ to 50μ. Another form of branching will also be present in which the closely set branches diverge at quite strong angles and are quite regularly constricted, presenting a moniliform appearance, and become eventually divided into short cells. These branches become more closely compacted and interwoven, forming rotund bodies at first white and quite small, but eventually 2 to 4 millimeters in diameter and of a brown color. These bodies are probably sclerotia.

Upon the surface of these sclerotia are diverging threads with numerous moniliform cells which resemble chains of conidia. These are not true conidia, since they do not easily become separated. By breaking down the sclerotia, or by scraping the surface, many of them become separated into chains of two or three cells or even become entirely separate. If placed in water, or in suitable medium, they will germinate, thus functioning like conidia.

The sclerotia have been kept for several months, but in no case has any other stage of the fungus been developed from them.

At present it can not be correlated with any known group of fungi, but there are reasons for supposing that the sclerotia may be the resting stage of some hymenomycetous fungus. Frequently the threads become united into rope like strands and change to a brown color.

DAMPING OFF BY VARIOUS FUNGI.

Several fungi, probably quite a large number, produce phases of damping off at certain times, while their evil effects are not confined to this peculiar class of injuries. *Phytophthora cactorum* (L. et C.) Schroeter (*Phytophthora omnivora de Bary*) was first discovered as the cause of decay of species of cactus in forcing houses. This fungus frequently destroys seedlings of trees, causing them to become brown and later to decay.

Several of the anthracnoses are known to produce genuine cases of damping off while their injury is by no means confined to this trouble. *Colletotrichum lindemuthianum* on bean seedlings is a good illustration of this, as Halsted[29] has already shown. The same author points out that a *Colletotrichum* on cuttings of albutilon, passiflora, clematis and jessamine causes them to damp off and in some houses ruins the bulk of the cuttings in the bed, while a *Gloeosporium* damp off rose cuttings.

Another anthracnose, *Colletotrichum gossypii* Southworth sometimes damps off seedling plants of cotton. Carnations are also affected in the same way by *Volutella dianthae* (Hals).

Halstead found a *Phyllosticta* in one case and in another case a *Septoria* growing in the stems of decaying chrysanthemums, and while this was the only fungus present it was not certainly determined as the cause of the trouble. According to Halstead bacteria also cause seedlings of cucumbers to damp off.

A species of *Botrytis* which is very common in forcing houses, producing a variety of diseases of various plants, frequently damps off leaves and twigs of cuttings or well rooted plants. When the houses are quite damp the fungus gains hold on the plant, probably in the axil of the leaf or branch, because the water is held at these points for a longer time, and once well seated in the tissue continues its work until the leaf or branch is rotted off. Leaves of begonias and branches of roses have been damped off in the horticultural houses at Cornell University.

A careful inquiry would probably reveal a large number of fungi which at times produce diseases almost if not quite identical with damping off so far as external appearance goes.

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[29] 4th Rept. N. Jr. Agr. Coll. Exp. Sta. 291, 1891.

TREATMENT.

In the treatment of this trouble especial attention must be given to the environment of the plants and those conditions which favor the rapid development of the parasites. These conditions are known in most cases to be high temperature accompanied by a large moisture content of the soil, humid atmosphere, insufficient light and close apartments, and soil which has become thoroughly infested with the fungi by the development of the disease in plants growing in the same. Some excellent notes on the treatment of the disease by gardeners and horticulturists are given in the American Garden for 1890, by Meehan, Massey, Maynard, Watson, Lonsdale, Gardiner, and Bailey, and a short description of the potting bed fungus (*Artotrogus debaryanus*) by Seymour. The principal lines of treatment suggested there from the practical experience of the writers are as follows:

When cuttings are badly diseased they should be taken out, the soil removed, benches cleaned and fresh sand introduced, when only the sound cuttings should be reset. For cuttings is recommended a fairly cool house, and confined air should be avoided in all cases. As much sunlight as possible should be given as the plants will stand without wilting. When close atmosphere is necessary guard against too much moisture and keep an even temperature. The soil should be kept as free as possible from decaying vegetable matter. This is a very important matter, for several of the most troublesome of the parasites grow readily on such decaying vegetable matter and in many cases obtain such vigorous growth that they can readily attack a perfectly healthy plant which could resist the fungus if the vegetable matter had not been there to give it such a start. Soil which is dry beneath and wet on top as results from insufficient watering by a sprinkler favors the disease more than uniformity of moisture throughout the soil.

In seed beds use fresh sandy soil free from decaying matter. Avoid over watering especially in dull weather, shade in the middle part of the day only and keep temperature as low as the plants will stand.

When seedlings are badly diseased it will be wise to discard them and start the bed anew. In the early stages however they can frequently be saved by loosening the soil to dry it, and placing the pots in sunny places at such times as they will not wilt. Some advocate sprinkling sulphur on the soil and in some cases sulphur at the rate of one to thirty is mixed in the soil before sowing with good effect. When the beds are badly infested Humphrey[30] advocates the entire removal of the soil, whitewashing the beds, and the introduction of fresh soil.

In houses heated by steam if it were possible to have, without too great expense, a steam chest where the pots and seed pans which are used could be placed and the soil thoroughly steamed for several hours it could be sterilized, and the finer and more delicate seedlings be grown then with little danger if subsequent care was used to not introduce soil from the beds. In testing the virulence of the *Artotrogus debaryanus* (Hesse), and of the sterile fungus, several experiments have been made by steaming pots of earth, growing seedlings in them and then inoculating some of the seedlings with the fungus while other pots were kept as checks, and all were under like conditions with respect to moisture, temperature, etc. The seedlings which were not supplied with the fungus remained healthy while those supplied with the fungus were diseased and many killed outright (see frontispiece).

CONCLUSIONS.

Damping off is caused by the growth in the seedlings or cuttings of fungus parasites which themselves are plants, but microscopic in size. The plants when affected frequently present a paler green color. The tissues become soft at the surface of the ground, the plant falls over and dies. No one fungus is concerned even in the soft rot of seedlings. In related cases the plant may show a brownish ulcer at the surface of the ground which frequently increases in size until the plant is severed at this point and then dies.

Too great a moisture content of the soil, air, high temperatures, close apartments, and insufficient light not only favor the rapid growth of the parasites but they also induce a weakly growth on the part of the seedling so that it cannot so readily resist the disease.

The parasites can grow and multiply on decaying vegetable matter which is in the soil.

When once in the soil they can remain alive for months even though the soil become dry or frozen.

Soil used in seed beds or cutting beds should be free from decaying vegetable matter or care should be used that the matter is thoroughly decomposed. Fresh sand is said to be the best for small seedlings.

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[30] Mass. State Agr. Exp. Sta. Bull. 402, 1891.

Soil in which plants have once been diseased should be discarded if it cannot be sterilized by steam heat for several hours. Fresh soil free from vegetable matter should be introduced.

Water the soil thoroughly but not to saturation and do not water oftener than actually needed.

Keep the houses well lighted, well supplied with fresh air. Do not have high temperatures, keep as even a temperature as possible. When the disease first sets in stir the soil about the plants and do everything possible to dry the soil without killing the plants or raising the temperature, keep the temperature as low as the plants will bear. If this does not save them change the soil and clean the beds by whitewashing them.

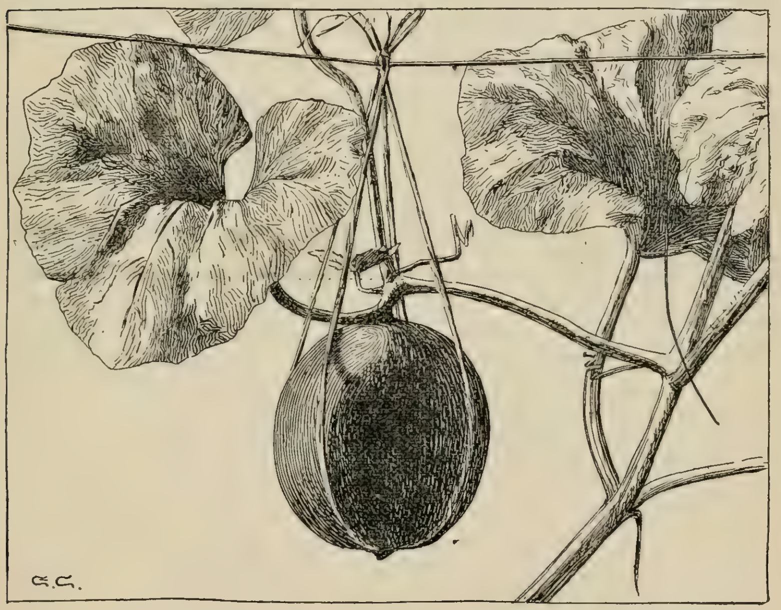
When cuttings become seriously diseased change them to fresh soil, resetting only the perfectly healthy ones.

GEO. F. ATKINSON.

BULLETIN 95—June, 1895.

Cornell University—Agricultural Experiment Station.
HORTICULTURAL DIVISION.

WINTER MUSKMELONS.



By L. H. Bailey.

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BULLETINS OF 1895.

84. The Recent Apple Failures in Western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
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92. Feeding Fat to Cows.
93. The Cigar-Case-Bearer.
94. Damping-off.
95. Winter Muskmelons.

Cornell University,
Ithaca, N. Y., *June* 15, 1895.

The Honorable Commissioner of Agriculture, Albany:

Sir.—The following account of winter muskmellons is submitted as a bulletin in pursuance of Chapter 230 of the Laws of 1895. The growing of winter crops of vegetables and flowers under glass is an important industry in New York State and one that is rapidly enlarging. It is the most intensive and one of the most highly specialized of all the branches of agriculture, and it must play an increasingly important part in the industrial development of the future. This Station has already entered this interesting field, particularly with contributions upon the cultivation of tomatoes, frame cucumbers, beans, cauliflowers, and the heating of forcing-houses and the influence of the electric arc light upon plants under glass. We are now glad to add this paper upon the melon, which is admittedly the most difficult vegetable crop to mature in the winter months, but which can no doubt often be added with profit to those houses which are fitted for the growing of frame cucumbers or tomatoes.

L. H. BAILEY.

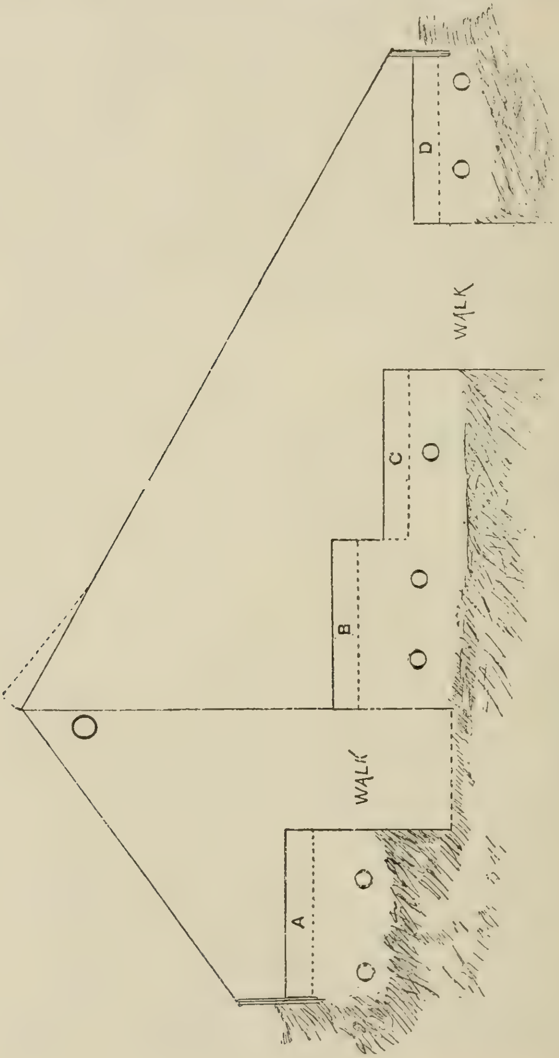
56.— Melon house, when the plants were four weeks from the pots.

Winter Muskmelons.

I. THE FORCING OF MELONS.

The forcing of melons for delivery in midwinter is practically unknown. The fruit is often grown as an early winter crop, ripening in October and early November, and the seeds are often sown in January and the melons matured in May and June. Gardeners now and then ripen a few melons in midwinter, but the fruits are almost invariably very poor or even disagreeable in quality. The writer has long been convinced that it is possible to secure good melons in December, January and February, and to grow them nearly as cheaply as the English or frame cucumbers. The attempt was first made in the winter of 1889–90, and it has been repeated more or less persistently until the present time. It was only until last winter when, profiting by all the pitfalls of our past experience and assisted by the services of our gardener, Michael Barker, we finally had a winter crop of good melons. In order to satisfy the reader's curiosity at the outset, I will say that the essentials for growing midwinter melons, as I understand them, are these: *High temperature from the start* (80° *to* 85° at mid-day, and 70° at night); *the plants must never be checked, even from the moment the seeds germinate, either by insects, fungi, low temperature, or delay in "handling; dryness at time of ripening; a soil containing plenty of mineral elements, particularly, of course, potash and phosphoric acid; polliniferous varieties; the selection of varieties adapted for the purpose.* All these requirements seem to be easy enough of attainment as one reads them, but it has taken us six years to learn them. Others would, no doubt, have been more expeditious; but it should be said that no one of these conditions will insure success, but *all of them must be put together.*

The House.— A house which is adapted to the growing of English cucumbers or tomatoes, should grow melons. The first requisite is heat. The capacity of the heating system must be sufficient to maintain a high temperature in the coldest weather. The house should be free of draughts and large leaks. Our melon house opens into sheds at both ends, so that no outside air ever blows into it; yet even here, we lock up the house from the time the melons begin to form, to prevent persons from passing through it. We like to keep the room close. It should be capable of being kept dry. There should be ample room over the benches for training the vines 5 to 6 feet. We use benches, for melons must have strong bottom heat.



57.—Cross section of melon house. Scale one-fourth inch to the foot.

Fig. 56 is a view in our melon house when the plants had been four weeks transplanted. For myself, particularly where such high temperatures are wanted, I prefer steam heat. A melon house should receive direct sunlight through an unshaded roof. In this respect melons differ from frame cucumbers, which generally thrive best under a shaded roof. The burning of the foilage by the sun is avoided by the use of glass which does not possess waves or varying thicknesses in the panes. The bubbles, flaws and "tear drops" in glass are not the cause of burning. Fig. 57 shows a cross-section of the house in which we have grown melons. We have used benches A, B and C. The lower bench, D, has too little head room and, being the lowest, it is too cold for melons.

The soil should be very fertile. We have had good success with clay sod, which had not been manured, pulverized and mixed thoroughly with about half the bulk of well-rotted stable manure. Such a mixture contains enough quickly available nitrogen to start the plants off strongly, whilst the mechanical condition of it is so friable that all the mineral elements are easily obtained by the plants. An occasional light application of potash and phosphoric acid worked into the soil will be found to be useful. Very much of the ultimate behavior of the plants will depend upon the proper selection and mixing of the soil, and one who has had no experience in forcing-house work will rarely obtain the best results for the first year or two in preparing the earth. The mechanical condition of this soil is really more important than its fertility, for plant food may be added from time to time, but the soil itself cannot be renewed whilst the crop is growing; and, moreover, the plant food is of little avail unless the soil is well drained and aerated, not too loose nor too hard. It is impossible to describe this ideal soil in such manner that the beginner can know it. Like many other subjects of handicraft, it can be known only by experience. It may help the novice, if I say that soil which will grow good melons in the field may not be equally good in the house. Under glass, with the fierce heats in full sunshine and the strong bottom heat, heavy watering, as compared with normal rainfall, is essential, whilst the rapid drainage and the evaporation from both the top and the bottom of the bed, impose conditions which are much unlike those of the field, But the ideal condition of the soil to be maintained in the house, may be likened to the warm, mellow, rich and moist seed bed in which every farmer likes to sow his garden seeds in spring.

There is no sub-soil indoors to catch the drainage, and a mellow field soil is often so loose and porous that the water runs through the benches and carries away the plant food. The house soil must therefore be retentive, but then there is danger that it will become puddled or sodden, or arrive in that condition which a gardener knows as a "sour" soil. This condition may be avoided by the use of the stable manure to add fiber to the soil, by the very frequent stirring of the immediate surface with a hand weeder, and particularly by great care in watering. As the fruits begin to mature, water the house very sparingly. "The less water given, the higher will be the flavor of the fruit."* Inasmuch as old or fruiting plants require a dry house and young plants thrive best in a moister atmosphere, it is not advisable to attempt to grow successive plantings of melons simultaneously in the same house.

The bench should not be above 7 inches deep, and perhaps 5 inches is better. If the soil is too deep, the plants grow too much and are late in coming into bearing. If the bench is 4 feet wide, two rows of plants, two and a half feet apart in the rows, may be grown; but if the bench is an outside one it may be handier in training if there is but a single row, with the plants about 18 inches apart. It should always be borne in mind, however, that at least twice the number of plants should be set in the beds which are ultimately to grow in them for there will almost certainly be accidents and black aphis, and mildew and damping off. When the plants have stood in the benches two or three weeks, the weak ones may be pulled out. It is a good practice, when but a single row is planted, to set the plants nearer one side than the other, and then leave the wider side of the bench empty, and add the soil to it as the plants need it. In this way fresh forage is obtained for the roots in soil which has not been leached of its plant food nor impaired in its mechanical condition; and the plants will make a steady growth from start to finish, rather than an over-vigorous one at first. If there is too much soil, the roots spread through it quickly and the plants run at once to vine.

Sowing and Transplanting.—The seeds should be sown in pots. We like to place a single seed in a 2-inch pot, and in about three weeks—if in summer or fall—to transplant the seedling into a 4-inch pot. In two or three weeks more, the plant may be set per-

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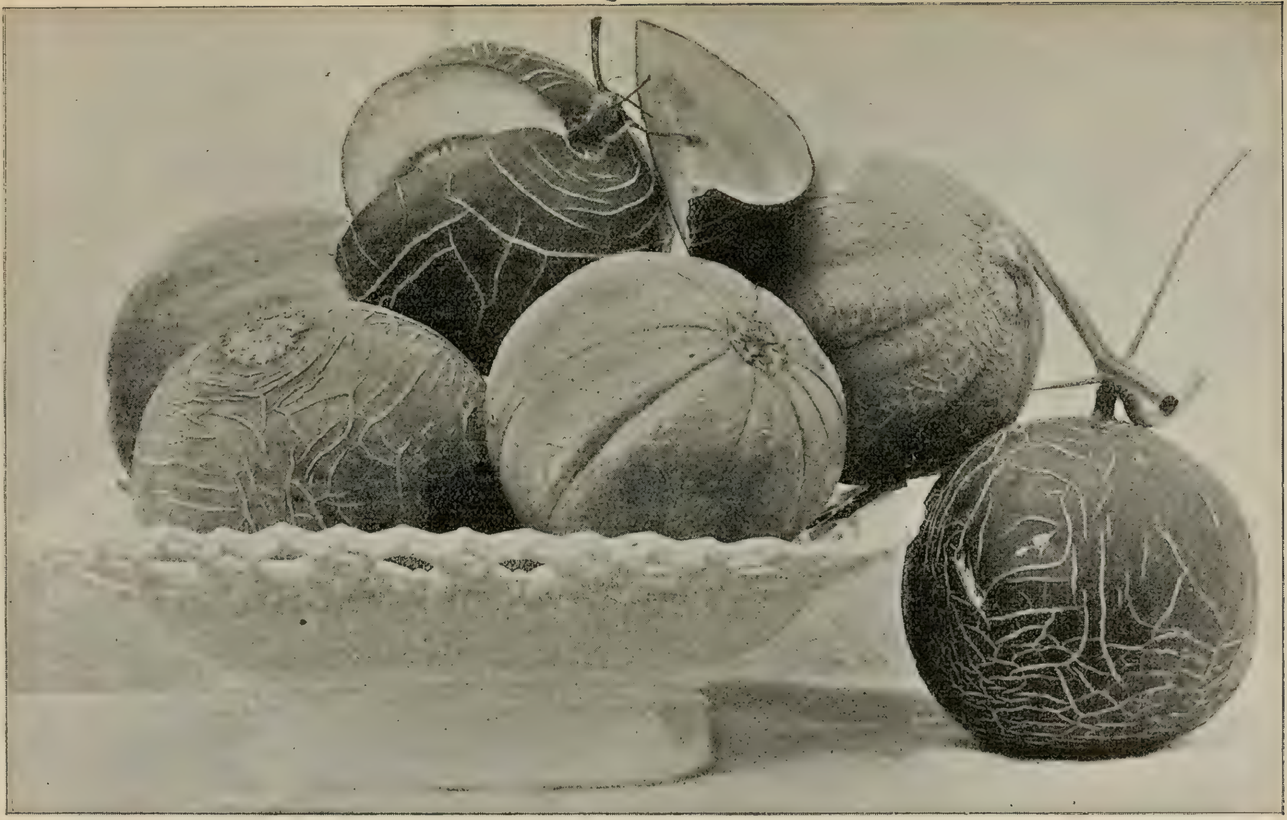
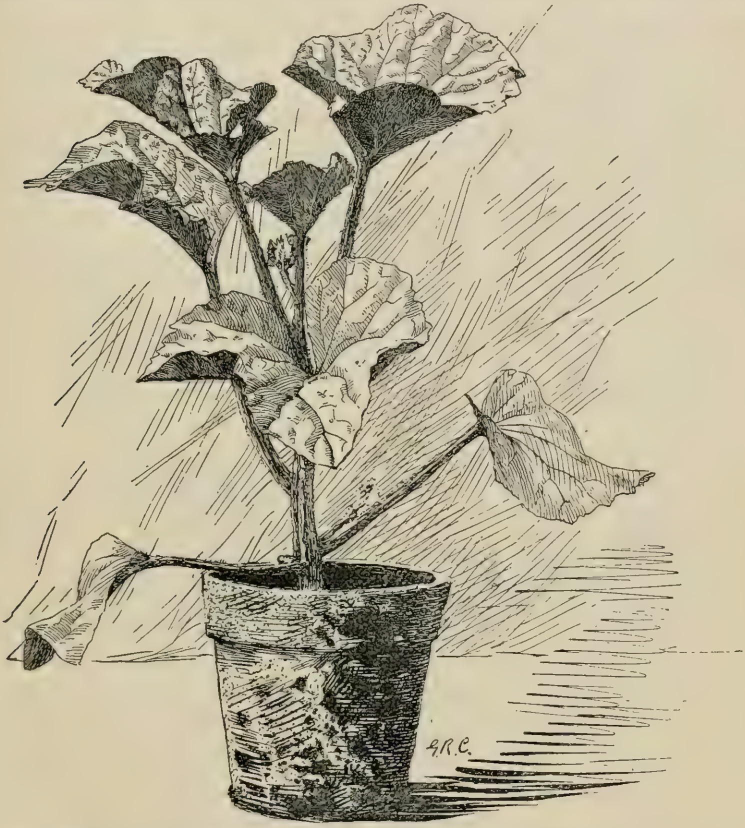
* George Mills, A Treatise on the Cucumber and Melon, 73.



61.— Winter melons, picked December 21, 1894 — the shortest day in the year. Top melon, cut, Hero of Lockinge ; front row, left, a form of Monarch ; front row, right, Masterpiece ; right end, Masterpiece ; left end, back, Blenheim Orange ; right end, on table, Empress.

62.—Blenheim Orange melon. Natural size.

manently in the bench. The record of one of our crops is as follows: Seeds sown August 4th; repotted August 30th; transplanted to bench September 10th; first fruit picked December 6th; crop all harvested for Christmas.* Fig. 58 shows the size of a good melon plant as it leaves a 4-inch pot for the bench. It is very important that the plants should not become pot-bound, nor stunted in any other way. It is only strong, pushing plants which give satisfactory results.



58—Melon plant fit for transplanting into permanent quarters. About ⅓ actual size. (In a 4-inch pot.)

Training.—The plants are "stopped"—the tip of the leader taken off—as soon as they become established in the bench, or sometimes even when they are transplanted. This pinching-in is practiced for the purpose of setting the plant at once into fruit-bearing, and to make it branch into three or four main shoots. All the weak or "fine" shoots are removed as fast as they appear, so that the plant does not expend its energy in the making of useless growth. The three or four main vines or arms are trained divergently upon a wire trellis, and as soon as a shoot reaches the top of the trellis — four or five feet — it is stopped. This trellis is made simply of light wire strung both horizontally and vertically, with the strands about a foot apart in each direction. To these wires, the vines and fruits are tied with raffia, or other soft cord. It must be remembered that the fruit is borne along the main branches, and that all small or "blind" growths should be nipped out as soon as they start. The fruits should hang free from the vine, never touching the ground. It will generally be necessary to hang them to a wire, as shown on the title-page, by making a sling of raffia. They will then not hang too heavily on the vine, nor break off — as they sometimes do if unsupported.

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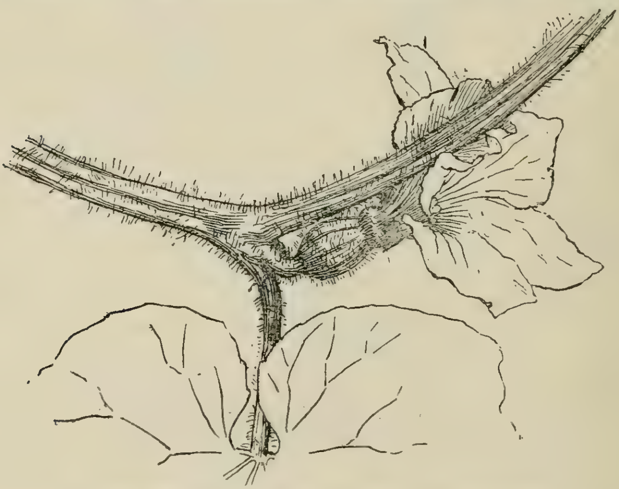
* It should be said that the forcing season at Ithaca is unusually cloudy, and that, consequently, these dates of maturity are somewhat later than they may be in sunnier regions.



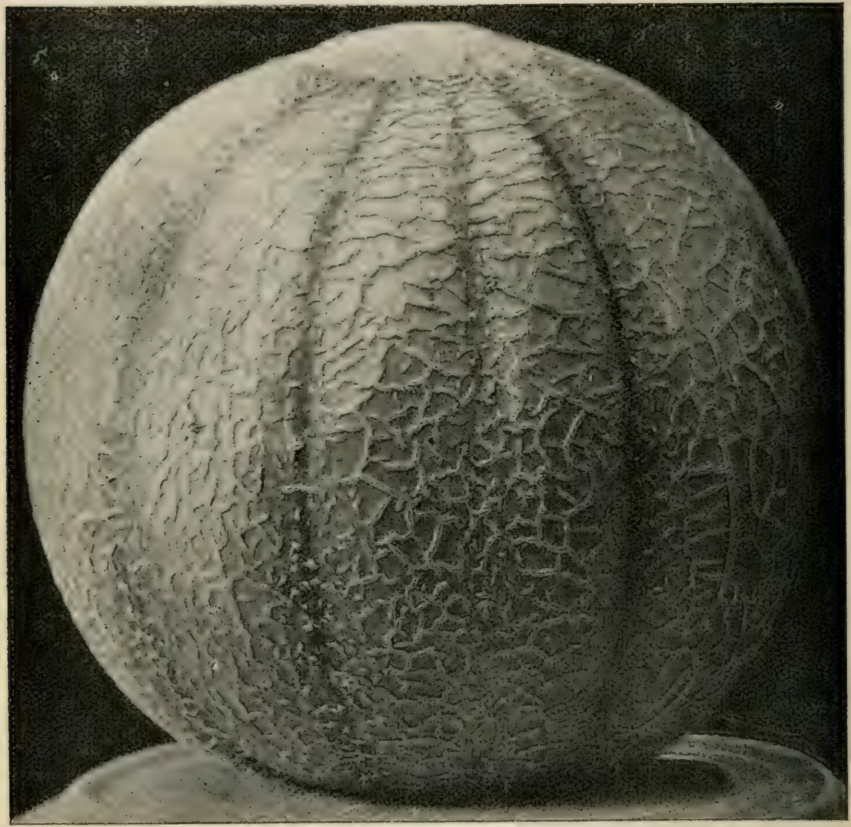
59 — Pistillate or female flower of melon. Natural size.

Pollinating. — The flowers must be pollinated by hand. Melons are monœcious — that is, the sexes are borne in separate flowers on the same plant. The first flowers to open are always males or staminate, and it may be two weeks after these first blossom appear that the females or pistillates begin to form. There is nearly always a much larger number of males than females, evens when the plant is in full bearing. Fig. 59 is a female, or pistillate flower, natural size. It is at once distinguished by the little melon, or ovary, which is borne below the colored portion of the flower. The male or staminate flower is seen in Fig. 60. It has no enlargement or melon below, and the flower perishes within a day or so after it opens. Pollination is performed in the middle of the day, preferably when the house is dry and the sun bright, so that the pollen is easily detached from the male flower. A male flower is picked off, the petal or leaves stripped back, and the central or pollen-bearing column is then inserted into a pistillate flower and there allowed to remain. That is, one male flower is used to pollinate one female flower, unless there should happen to be a dearth of male flowers, in which case two or three female flowers may be dusted with one male. If the house is too cool and too moist, the pollen will not form readily, and there are some varieties which are poor in pollen when grown under glass. Every pistillate or female flower, except the first two or three which appear, should be pollinated, although not more than four or five on each plant should be allowed to perfect fruit. It is very rare that even half of the female flowers show a disposition to set fruit. It is best to ignore the very first flowers which appear, for if one strong fruit is set much in advance of the appearing of other pistillate flowers, it will usurp the energies of the plant and the later fruits will be likely to fail.

60.—Staminate or male melon flower. Natural size.

Varieties.— The general varieties of field melons do not succeed well in the house. We have tried various common melons for forcing, but the only one which was adapted to the purpose is Emerald Gem. We have had the best success with the English frame varieties, particularly with Blenheim Orange. All these melons are small (winter specimens weighing from 1¼ to 1½ lbs.), with thin netted rinds and a red or white flesh of high quality.

Blenheim Orange (Fig. 62) is a red-fleshed melon of medium to medium large size, with a very irregularly and variously barred rind, scarcely ribbed, short-oval in shape, highly perfumed and of the very highest quality. This has been our favorite winter melon. In midwinter we have had it with all the characteristic flavor and aroma of autumn fully developed. It is also an early melon, in season coming in just after Emerald Gem.

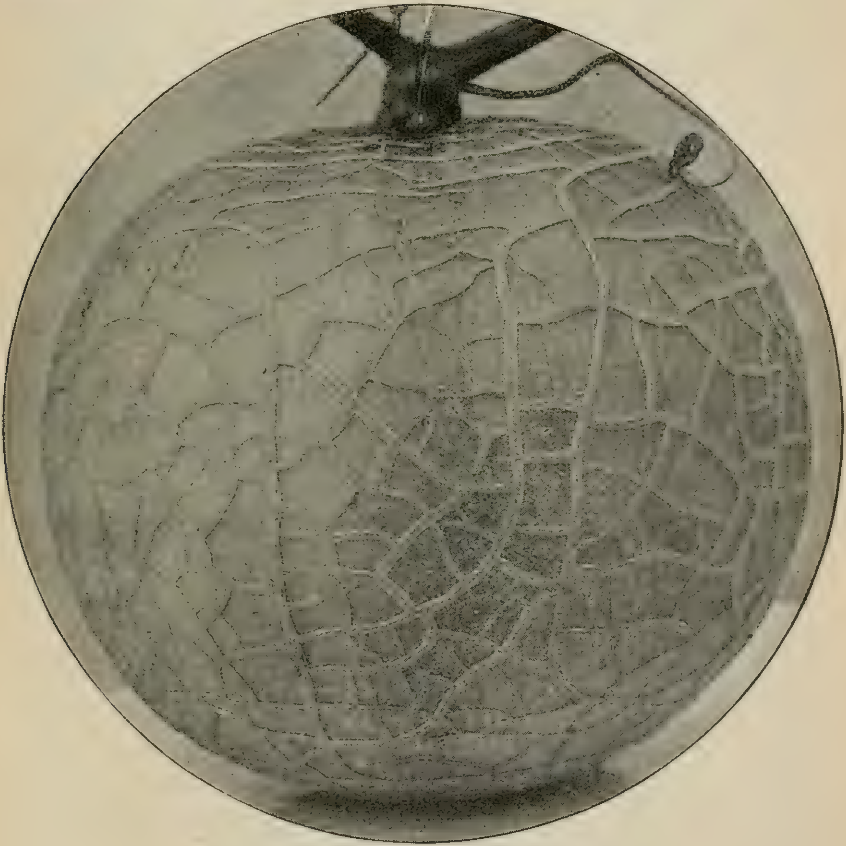


63.— Masterpiece melon. Natural size.

Hero of Lockinge (Fig. 61, the cut melon on top). This ripens just after Blenheim Orange. It is a firm melon of medium size, with white flesh, dark in color, with few very prominent irregular bars, not ribbed, globular, the flesh tender and excellent but less aromatic than Blenheim. This is one of the best of the frame melons.

Lord Beaconsfield follows Lockinge, but it has not been valuable with us. It is a dull green globular-conical misshapen melon without ribs or netted markings, and a soft green flesh which is poor.

Masterpiece (Fig. 63). A very attractive melon with distinct ribs or segments and a closely and prominently reticulated rind; globular-oval, of medium size, becoming yellow, with a thick and very rich red flesh. One of the very best, ripening ten days or two weeks after Blenheim Orange.



64.—Empress melon. Nearly natural size.

Empress (Fig. 64). A globular melon of rather small size, ribless, but marked with very coarse angular bars; flesh pale orange, of good quality. A pretty little melon, with curious markings, ripening with Masterpiece. Less desirable than Blenheim or Masterpiece.

Monarch (Fig. 61, front row, left). A good sized melon, with sparse markings, except about the blossom end, dull yellow in color, not ribbed; flesh thick and solid, red, of excellent flavor. Ripens with Masterpiece. Our stock of this melon appears to have been mixed, and we have also grown a cross with Lockinge. Because of its variable character and somewhat unattractive appearance, we prize it less than some other varieties; but it is probable that a pure stock would have given more satisfactory results.

The varieties, then, which we chiefly recommend for forcing, are Blenheim Orange, Hero of Lockinge, and Masterpiece, with, perhaps, Emerald Gem for early. A good crop of melons in the winter months is an average of three fruits to the plant. This means that some plants must bear four or five melons, for there will almost certainly be some plants upon which no fruit can be made to set. The larger the fruits, the fewer each plant can mature. Four to five pounds of fruit to the vine is all that can reasonably be expected after November. The fruits will continue to ripen for a week after they are picked. Ordinarily, if seeds of Emerald Gem, Blenheim Orange, Hero of Lockinge, or other early varieties are sown August first, fruits may be expected early in November. If the fruits are desired in January, there should be two to three weeks' delay in sowing. All plants grow slowly in the short, dark days of midwinter. The novice should not attempt to secure fruits later than Christmas time, for the growing of melons should be undertaken cautiously at first.

Insects and diseases.— There have been three serious insect enemies to our winter melons — black aphis, mites (*Tetranychus bimaculatus*) and mealy-bug. The best method of dealing with these pests is to keep them off. It is a poor gardener who is always looking for some easy means of killing insects. If the plants are carefully watched and every difficulty met at its beginning, there will be no occasion for worrying about bugs. A fumigation with tobacco smoke twice a week will keep away the aphis; but if the fumigation is delayed until after the lice have curled up the leaves, the gardener will likely have a serious task in overcoming the pests, and the plants may be irreparably injured in the meantime.

For mites, keep the house and plants as moist as possible. At all events, do not allow the plants to become so dry that they wilt, for this neglect will sap the vitality out of any plant, and it falls an easy prey to insects. When the mites first appear upon the foliage,—if the gardener should be so unfortunate as to have them,—knock the pests off with a hard stream of water from the hose, or pick the affected leaves and burn them. If the plants become seriously involved, so that all the leaves are speckled-grey from the work of the minute pests on the under side, then, destroy the plants. Melon plants which have become seriously checked from the attacks of insects or fungi are of no further use, and they may as well be destroyed first as last.

Mealy-bugs are easily kept off by directing a fine hard stream against them, when watering the house. When these bugs first appear, they usually congregate in the axils of the leaves, and a strong stream of water greatly upsets their domestic arrangements. In one of our melon experiments, when the mealy-bug got a foothold, we picked them off with pincers. We went over the vines three times, at intervals, and eradicated the pests; and the labor of it — the vines were small — was much less than one would suppose.

There are two troublesome fungous disorders of frame melons. One is the mildew (*Erysiphe Cichoracearum*), which appears as whitish mold-like patches on the upper surface of the leaves. It also attacks cucumbers. It may be kept in check by evaporating sulphur in the house, as described in Bulletin 96. It is imperative that the sulphur do not take fire, for burning sulphur is fatal to plants.

The second fungus is canker or damping-off.* This usually attacks the plants after they have attained some size in the benches, sometimes even when they are in fruit. The vine stops growing, turns yellow, and finally begins to wilt. If the plant is examined at the surface of the ground and just beneath the soil, the stem will be found to be brown and perhaps somewhat decayed, the bark sloughs off, and sometimes deep ulcers are eaten into the tissue. In this stage of the disease nothing can be done to save the plant. The treatment must be a preventive one. Keep the soil dry about the stem. Do not apply water directly at the root. In order to keep the soil dry, it is an excellent plan to hill up the plant slightly. If a little sulphur is mixed with the soil about the plant, the spread of the fungus will be checked. Some persons sprinkle lime about the plant to check the fungus.

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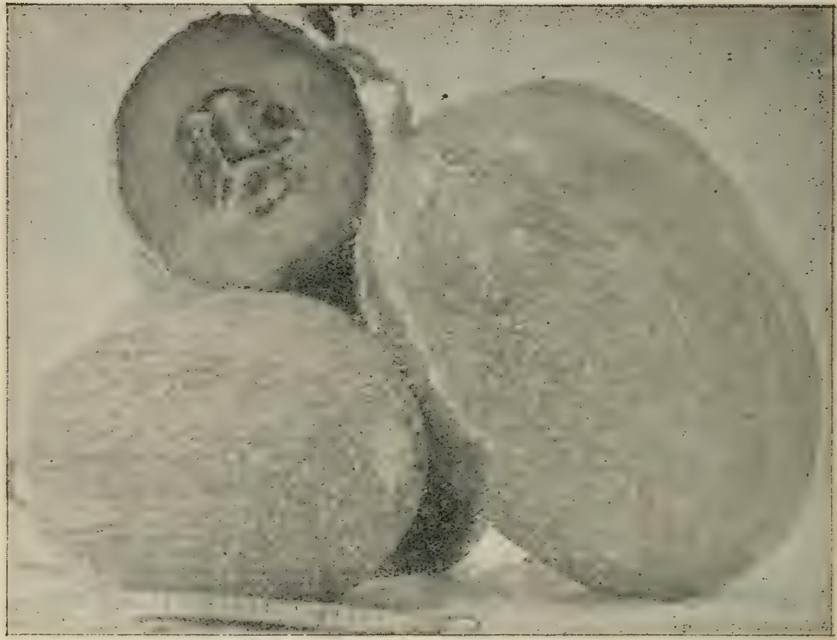
* For a discussion of this fungus by the botanist, see Bull. 94, p. 303.

II. WINTER MELONS FOR FIELD CULTIVATION.

There is an interesting class* of melons little known in this country, which gives fruits of long-keeping qualities. These are known as the winter or scentless melons. They are mostly of an oblong shape, with green or grayish hard rinds and commonly a white or green flesh which often lacks almost entirely the characteristic aroma of the muskmelon. The leaves are generally longer and greener than those of the common melons. The fruits are picked just before frost, when they appear to be as inedible as squashes, and are stored in a fruit-room to ripen. The true winter melons require a long season. We have planted them upon good soil on the first day of June, and they have barely come to maturity before



65.—Winter Climbing Nutmeg Melon.

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* *Cucumis Melo,* var. *inodorus,* Naudin, Ann. Sci. Nat. Bot. 4th ser. II, p. 56.

frost. There is little difficulty in keeping some of the varieties until Christmas, if they do not get too ripe in the field, if the fruits are not allowed to become frost-bitten, and if the room is cool and rather dry.

There are two general types amongst the winter melons which we have grown. One type has a solid interior, like a cucumber, and the seeds are imbedded firmly in the structure of the fruit. The other class has a soft interior and the loose seeds of ordinary melons. To the first class belongs the Winter Pineapple, a variety which seems to me to be indistinguishable from the Green-fleshed Maltese melon (*Melon de Malte d' Hiver à chair verte*) of the French. It is variable in shape and size but is commonly pyriform and clear yellowish green, with a green inodorous flesh of fair quality for its class.

66.—White Japan Melon.

There are a number of good varieties in the second, or loose-seeded class. The one which we have liked best is the French Winter Climbing Nutmeg (*Melon Brodé verte grimpant*), shown in Fig. 65. This photograph (Fig. 65) was taken in November, when the fruits had become somewhat shriveled. It has a sweet and good green flesh. The seeds are very small. The fruit is small, ribbed, and very dark green with yellow furrows. It keeps well until December. Another good melon is the White Antibes of the French (*Melon Brodé d' Antibes blanc d' Hiver à chair verte*). It is an egg-shaped melon of good size, bright green until full maturity, and hard-shelled. It is a very long keeper. The Red-fleshed Maltese melon excels other melons of this class in quality, the flesh being aromatic and rich, but it is not so good a keeper as the green-fleshed sorts.

The White Japan melon (Fig. 66), whilst not a winter variety, is nevertheless a good keeper if the fruits are not fully ripened when picked. We have kept it easily until well into November. It is a small globular lemon-yellow melon, of variable character as regards surface markings, a soft and stringy but good and aromatic flesh, and many small seeds. The blossom scar is usually very large, as seen in the specimen at the right in Fig. 66.

In general, I should say that these winter melons are worth growing for home use. The quality is not so good as that of the summer melons, but this defect is overbalanced by their long-keeping qualities. From my present knowledge of them, I should grow chiefly the Winter Climbing Nutmeg, the White Antibes and perhaps the Winter Pineapple. These melons are also useful for the making of conserves.

SKETCH.

1. Muskmelons for winter use may be obtained in two ways — by forcing them under glass, and by growing the long-keeping varieties in the field.

2. Melons under glass are usually harvested in late fall or in spring in this country. It is difficult to bring them to a good size and high flavor in the winter months, although this can be done if the proper conditions are secured.

3. The requisites for ripening melons under glass, particularly in winter, are these: A temperature of 80° to 85° at midday in the shade, and 10° to 12° lower at night; a continuous and steady growth from the time the seeds germinate; a soil rich in mineral elements and without much stimulating nitrogen; dryness at time of ripening; great care in preventing the attacks of insects and

fungi; hand pollination; the selection of varieties adapted for the purpose.

4. The melon house should have all the direct sunlight which is obtainable, and it should be capable of being easily heated. There should be a space of five or six feet above the benches, to allow of training, but all height beyond this is of little avail. Melons demand unshaded roofs.

5. Muskmelons should be grown in benches, with strong bottom heat, such as is supplied to frame cucumbers and tomatoes. The soil should be five or six inches deep, and each plant should have about four square feet of ground room. But it must always be remembered that, because so many accidents are likely to overtake the plants, two or three times the number of plants should be transplanted into the benches which it is designed shall ultimately stand there.

6. A soil made of pulverized strong clay sod mixed with half its bulk of old manure, is fit for melons. Raw, fresh manure gives too much stimulating growth. Subsequent fertilization may be effected by applications of liquid manure or mineral fertilizers.

7. Young and rapidly growing melon plants demand free watering, and a moist atmosphere always keeps down the mite and red spider; but when the fruit begins to ripen, and when the flowers are being pollinated, the house must be dry. It should be borne in mind, however, that a moist atmosphere at any time encourages mildew and canker.

8. The house should be ventilated cautiously, and all draughts and sudden changes in temperature should be avoided.

9. Early varieties mature fruits in three months from the seed, except in midwinter, when considerably more time must be allowed. The seed are sown in thumb-pots or 2-inch pots, repotted into 4-inch pots, and thence transplanted to the benches. The plants must never be allowed to become pot bound.

10. The plants are "stopped" before they show a tendency to run, and three or four strong shoots are trained upwards on a wire trellis. All weak secondary growths should be removed as soon as they start. These main shoots are stopped when they reach a height of about four feet.

11. Melon flowers must be hand-pollinated. This operation is best done in a sunny day, when the house is dry.

12. Good varieties for house use, in order of ripening, are Emerald Gem, Blenheim Orange, Hero of Lockinge and Masterpiece. The best single one in this list is probably Blenheim Orange.

13. From November until spring, a good melon should weigh from 20 to 24 ounces, and an average of three melons to the plants is all that can be expected. Before November a heavier yield may be obtained.

14. The insects which have seriously troubled muskmelons in our houses are the black aphis, two spotted mite and mealy bug. Fumigating with tobacco twice a week will keep the aphis out. A moist atmosphere holds the mite in check. Knock off the mealy-bug with a hard stream from the hose.

15. Two fungi attack winter melons. The mildew, appearing as frosty patches upon the leaves, is destroyed by sulphur fumes. The canker or damping off is best prevented by keeping the soil dry about the plants and by mixing sulphur in the soil.

16. Winter melons for field cultivation require a long season, and they are picked just before the frost and before they have become edible. They ripen slowly in a cool fruit room, often keeping until Christmas. Some of the leading varieties are Winter Climbing Nutmeg, White Antibes and perhaps Winter Pineapple. These melons are mostly lacking in aroma and they do not have the high quality of other melons.

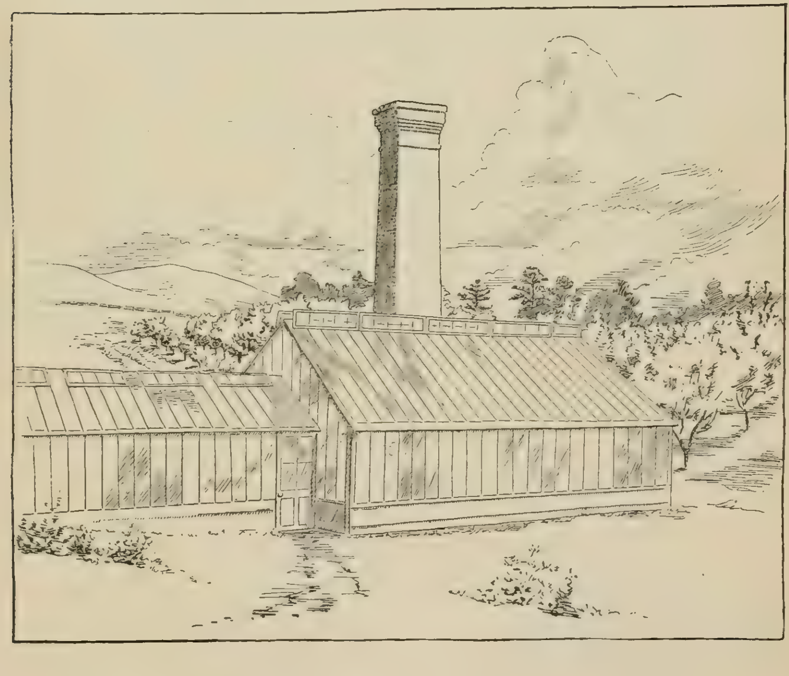
L. H. BAILEY.

BULLETIN 96—June, 1895.

Cornell University—Agricultural Experiment Station.

HORTICULTURAL DIVISION.

Forcing-House Miscellanies.



By L. H. Bailey and E. G. Lodeman.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in Western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. On the Effect of Feeding Fat to Cows.
93. The Cigar-Case Bearer.
94. Damping-Off.
95. Winter Muskmelons.
96. Forcing-House Miscellanies.

CORNELL UNIVERSITY,
ITHACA, N. Y., *June* 26, 1895.

The Honorable Commissioner of Agriculture, Albany:

SIR.—The prolific requests of correspondents and the suggestions which come of experiment station investigation, are bound to result in the accumulation of many pieces of work which are more or less fragmentary and which are of insufficient length or importance for separate publication. Some of the more valuable of such investigations relating to the forcing-house industry, which have recently accumulated, are here gathered and sorted into convenient form for preservation; and I take the liberty to suggest the publication of them as a bulletin under chapter 230, of the Laws of 1895.

L. H. BAILEY.

CONTENTS.

Remarks upon the Heating of Forcing-Houses. L. H. Bailey.

Advises steam in preference to water for heating all large forcing establishments which are frequently modified or extended and where the runs are devious and crooked, particularly if a high temperature is required. Finds a high expansion tank to be more useful than a low one, in heating with water in closed circuits. Reports satisfactory results with illuminating gas as a fuel.

Lettuce. L. H. Bailey.

The requisites for growing lettuce under glass are a low temperature, solid beds or at least no bottom heat, a soil free of silt and clay but liberally supplied with sand, and careful attention to watering. Rot and leaf-burn are prevented by a proper soil and temperature, and care in watering and ventilating.

Celery under Glass. L. H. Bailey.

Describes the growing of celery for delivery in May and June, when the supply of stored celery is exhausted.

Cress in Winter. L. H. Bailey.

Forcing Egg-plants. E. G. Lodeman.

Egg-plants can be successfully grown under glass, but they require a very long season, a high temperature and full sunlight. Insects are troublesome, particularly the two-spotted mite, which is best handled by not allowing it to gain a foothold. Early Dwarf Purple is the best variety for forcing.

Winter Peas. E. G. Lodeman.

The tall or half-dwarf peas force readily in a cool house. The very dwarf varieties yield too little to pay for growing.

Bees in Greenhouses. E. G. Lodeman.

Details a vain attempt to utilize bees in pollinating tomatoes.

Methods of controlling Greenhouse Pests by Fumigation. E. G. Lodeman.

Bugs do no harm when absent. We should therefore treat the greenhouse rather than the bugs, that we may not have them. Instructions are given for the use of tobacco smudge, bisulphide of carbon, hydrocyanic gas and sulphur.

Treatment of Carnation Rust. E. G. Lodeman.

Copper fungicides are efficient.

Forcing-House Miscellanies.

REMARKS UPON THE HEATING OF FORCING-HOUSES.

The only system of heating now in use in large forcing-houses in this country is that of the closed circuit, in which the warming medium is conducted through small wrought-iron pipes, which may be laid either above or below the benches. The warming medium is either steam or water, and there are strong partisans of each. We had never taken sides in the controversy over the comparative merits of the two, for we have believed that each has superlative merits for particular purposes. Various tests which we have made, however, show that in large, unshaded forcing-houses, where the runs are various and crooked, and especially where high temperatures are wanted — as in forcing tomatoes, melons and cucumbers — steam has distinct advantages over water. Our first experiment was made in the winter of 1891–2, and the results were published in Bulletin 41. The general practical results of this test — which was an extended one — were these :

1. The temperatures of steam pipes average higher than those of hot water pipes, under common conditions.

2. When the risers or flow pipes are overhead, the steam spends relatively more of its heat in the returns, as bottom heat, than the water does.

3. The heat from steam distributes itself over a great length of pipe more readily than that from hot water ; and steam, therefore, has a distinct advantage for heating long runs.

4. Steam is preferable to hot water for long and crooked circuits.

5. Unfavorable conditions can be more readily overcome with steam than with water.

In this first experiment the steam system was more economical of coal than the water system, although we were then convinced that there was no necessary important difference between steam and water in economy of fuel. Objections were made to our conclusions by partisans of water heating, largely upon the score that our water heater was not a good apparatus. This objection had little merit, however, because our conclusions were drawn from observations made upon the heat-carrying power and mechanical movements of the two media, and these fundamental results must have been approximately the same in whatever style of heater was used. However, we repeated the test the following winter (Bulletin 55) under conditions particularly favorable to the water system. In this case, a portable water heater was used alternately for water and steam heating, the piping and other conditions being constructed for water and remaining the same for both media. The essential results of the first test were reaffirmed, except that the coal consumption was practically the same in the two systems.

In this second test, we took up a few points for more particular study. One of these was the effect of crooks and angles upon the movements of steam and water. Our conclusion was that

6. The addition of crooks and angles in pipes is decidedly disadvantageous to the circulation of hot water, and of steam without pressure; but the effect is scarcely perceptible with steam under low pressure.

Figures show this admirably. A straight run of riser or flow 21 feet long, had a piece some over 2 feet long cut out of it, and a set-off or crook put in its place by running the pipe out sidewise, at right angles, about four feet, letting the set-off re-enter the riser at the expiration of the two feet. That is, instead of a continuous piece of pipe, we had a pipe with four angles or elbows in it. The temperatures of the inside of the pipes were taken at the boiler and at the far end of the riser, both with steam and water and with and without the set-off. A part of the records were as follows:

A. Water Circulation.—

1. Straight run. Dec. 22—Jan. 16
    Average temperature at boiler .... 159°
    Average temperature at far end of riser .... 145°
2. With set-off. Feb. 10–25
    Average temperature at boiler .... 178°
    Average temperature at far end of riser .... 131°

B. Steam Circulation, no preceptible pressure on the guage.—

1. Straight run. Jan. 16–31
    Average temperature at boiler .... 204°
    Average temperature at far end .... 184°

2. With set-off. Jan. 31–Feb. 10	
Average temperature at boiler	193°
Average temperature at far end	123°
C. Steam Circulation, 1 lb. or more pressure.—	
1. Straight run. Jan. 16–31	
Average temperature at boiler	211°
Average temperature at far end	212°
2. With set-off. Jan. 31–Feb. 10	
Average temperature at boiler	211°
Average temperature at far end	212°

It is thus shown (*A*) that whilst the readings at the two ends of the run, with water, were very nearly the same in the straight pipe, they were widely different when the crook or set-off was inserted. Not only was the temperature at the farther end less with the crooked run than with the straight one, but the temperature at the boiler was much higher, showing that the impediment had increased the pressure and consequently the temperature in the fore part of the run. This explains why it is that water pipes are often so hot near the boiler but so cold at the further end of the house: some impediment, like crooks, dips, elbows or partially filled pipes, is probably in the circuit. With steam under low pressure, however (*C*), there was no difference in the temperatures at the two ends between the straight and crooked runs.

Another point receiving attention in the second experiment was the time required to heat up steam and water systems. It is said by many persons that inasmuch as water begins to move before steam forms, therefore hot water will warm up a house sooner than steam. It is true that water moves off first but it travels slower; it is soon overtaken by the steam. Our tests showed that

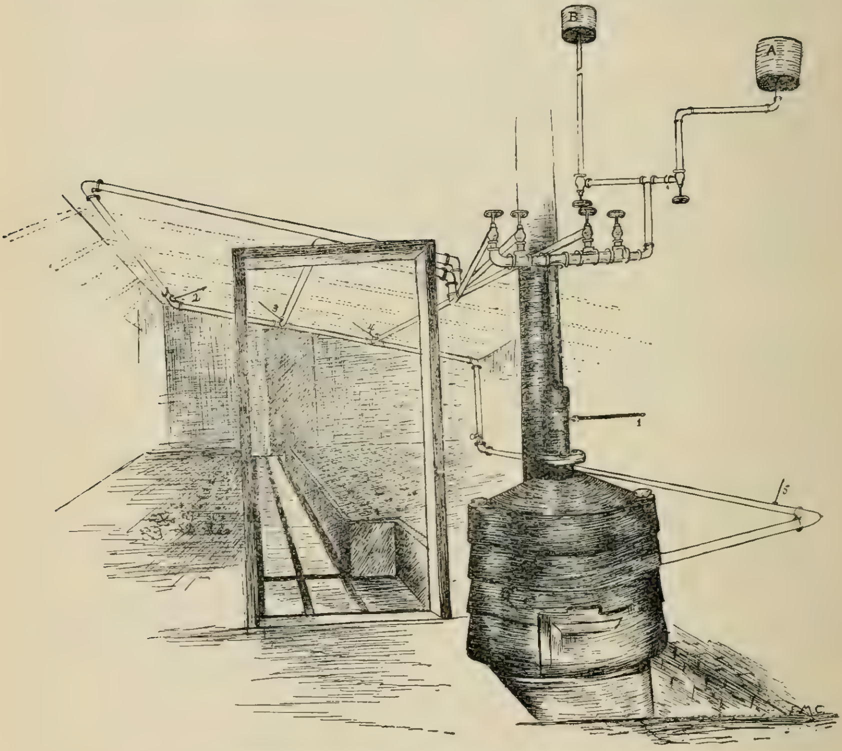
7. In starting a new fire with cold water, circulation begins with hot water sooner than with steam, but it requires a much longer time for the water to reach a point where the temperature of the house is materially affected than for the steam to do so.

We also found that

8 The length of pipe to be traversed is a much more important consideration with water than with steam, for the friction of the water upon the pipe is much greater than the friction of steam, and a long run warms slowly with water.

9. It is necessary to exercise greater care in grading pipes for water heating than for steam heating. With steam, a satisfactory fall towards the boiler is much more important than the manner of laying the pipes.

In the winter of 1893–4 a third series of tests was made. There were two objects in view: to again compare water and steam, and to determine the effect of different pressures upon the water system, by using high and low expansion tanks. The house and heater were the same as those used in the second test (Bulletin 55),— a lean-to lettuce house 16x27 ft., and a Novelty Hot Water Circulator furnished by the Model Heating Co., Philadelphia. Fig. 67 shows the apparatus set up. Three $1\frac{1}{4}$ inch risers or flow pipes run just under the roof, all uniting into one return. A delicate thermometer was let into each riser at the farther end (Nos. 2, 3, 4), and one into the return (No. 5) near the heater. Another was inserted in the riser (No. 1) just above the heater. These recorded the inside



67.— Experimental Heating Apparatus.

temperature of the runs, for the naked bulbs were let into the very centers of the pipes. Two expansion tanks were provided one (A) ten feet above the top of the heater, and another (B) twenty feet above it. Either one or both of these could be shut off by means of a valve. The heater is designed for water and the pipes were laid for water, being higher at the farther end. When the apparatus was used for steam, the water was simply lowered in the heater reservoir so as to make room for evaporation, and the piece of 4-inch pipe which led out of the top of the heater served for a steam dome. Of course the expansion tanks were shut off when steam was running. The advantages, therefore, were again in favor of the water system, but all our former conclusions respecting the superiority of steam over water, for the conditions given, were reaffirmed.

The following tables give the detaled results of the various tests:

A—WATER — Low Expansion Tank.

OBSERVATIONS.	Outside temperature.	House temperature.	Thermometer No. 1.	Thermometer No. 2.	Thermometer No. 3.	Thermometer No. 4.	Thermometer No. 5.	Average therm. readings.
December 9, 10.00 a.m.	38	54	212	65	150	....	170	149
December 10, 10.45 p.m.	38	56	180	....	155	....	162	165
December 10, 5.30 p. m.	32	54	180	....	163	....	157	166
December 11, 7.45 a. m.	18	44	207	182	170	....	175	183
December 11, 5.30 p. m.	20	54	205	182	120	....	110	154
December 12, 7.30 a. m.	38	50	135	122	120	....	116	123
December 12, 5.00 p. m.	20	50	210	193	171	....	175	187
December 13, 8.00 a. m.	10	46	202	186	173	....	170	182
December 13, 5.30 p. m.	9	44	195	175	169	....	166	176
December 14, 7.30 a. m.	12	50	193	160	163	....	164	170
December 14, 6.00 p. m.	21	46	214	190	194	....	190	197
December 15, 8.30 a. m.	32	50	195	162	167	....	163	171
December 15, 5.00 p. m.	45	56	150	130	133	132	135	136
December 16, 8.00 a. m.	50	60	188	169	150	161	155	164
Averages	27	51	190	159	157	146	157	.....
December 17, 5.00 p. m.	28	49	165	150	145	155	141	151
December 18, 7.45 a. m.	20	48	170	147	140	162	116	147
December 18, 5.00 p. m.	30	60	190	170	175	165	165	175
December 19, 7.45 a. m.	34	50	200	180	185	165	170	180
December 19, 5.00 p. m.	30	50	212	195	182	179	173	188

December 20, 8.00 a. m	14	42	175	153	138	143	140	149
December 20, 5.00 p. m	20	56	214	194	176	197	183	192
December 21, 9.00 a. m	32	58	200	183	186	170	173	182
December 21, 5,00 p. m	40	58	185	170	173	159	160	169
December 22, 8.00 a m	36	52	145	125	135	125	123	130
Averages	28	52	185	166	163	162	154	.....
January 25, 8.00 a. m	19	58	214	187	190	194	186	194
January 25, 5.00 p. m	16	56	205	160	179	170	168	176
January 26, 8.00 a. m	9	48	189	170	172	161	160	170
January 26, 5.00 p. m	26	54	196	177	177	168	167	177
January 27, 9.00 a. m	24	58	212	195	185	180	181	190
January 27, 5.00 p. m	30	58	180	160	161	150	152	160
January 28, 10.00 a. m	28	68	214	169	190	180	187	188
January 28, 5.00 p. m	35	60	208	140	189	179	179	179
January 29, 10.00 a. m	30	60	208	184	193	198	182	193
January 29, 5.00 p. m	36	58	195	173	173	180	170	178
January 30, 8.00 a. m	26	54	197	178	178	182	170	181
January 30, 5.00 p. m	30	60	215	183	208	205	197	201
January 31, 8.00 a. m	30	60	195	167	183	164	169	175
February 1, 8.00 a. m	24	60	....	166	163	180	185	173
February 1, 5.00 p. m	24	60	208	153	190	104	166	182
February 2, 8.00 a. m	18	54	190	142	160	165	162	163
February 2, 5.00 p. m	28	58	190	166	165	158	157	167
February 3, 8.00 a. m	20	56	170	157	155	149	143	154
February 5, 8.00 a. m	10	54	210	193	180	179	172	186
February 5, 5.06 p. m	22	58	200	173	176	172	160	176
February 6, 8.00 a. m	15	48	190	167	162	157	160	167

A—WATER—LOW EXPANSION TANK—(*Concluded*).

OBSERVATIONS.	Outside temperature.	House temperature.	Thermometer No. 1.	Thermometer No. 2.	Thermometer No. 3.	Thermometer No. 4.	Thermometer No. 5.	Average therm. readings.
February 6, 5.00 p. m.	32	60	195	168	165	160	161	169
February 7, 8.00 a. m.	29	54	212	187	178	174	177	185
February 7, 5.00 p. m.	40	62	190	169	165	162	162	169
February 9, 8.00 a. m.	32	54	200	180	180	170	170	180
February 9, 5.00 p. m.	38	58	201	179	182	174	174	182
Averages	25	57	199	170	176	173	169	.....

B — WATER — HIGH EXPANSION TANK.

OBSERVATIONS.	Outside temperature.	House temperature.	Thermometer No. 1.	Thermometer No. 2.	Thermometer No. 3.	Thermometer No. 4.	Thermometer No. 5.	Average therm. readings.
December 16, 5.00 p. m.	44	63	208	189	180	195	183	191
December 17, 7.00 a. m.	28	52	180	162	152	165	155	162
Averages	36	57	194	175	166	180	169	......
December 22, 5.00 p. m.	41	58	203	180	182	168	170	180
December 23, 8.30 a. m.	48	61	205	181	180	191	172	185
December 23, 5.00 p. m.	50	62	183	166	160	170	157	167
Averages	46	60	197	175	174	176	166	......
January 15, 5.00 p. m.	46	62	224	199	171	186	189	193
January 16, 8.00 a. m.	44	60	208	198	196	187	182	194
January 16, 5.00 p. m.	34	64	212	130	181	168	182	174
January 17, 8.00 a. m.	30	58	190	121	170	175	164	164
January 17, 5.00 p. m.	34	60	207	160	180	194	178	183
January 18, 8.00 a. m.	32	50	204	182	170	190	176	184
January 19, 5.00 p. m.	38	58	195	176	175	181	170	179
January 19, 8.00 a. m.	30	58	215	192	200	206	195	201
January 19, 5.00 p. m.	36	58	214	194	201	206	190	201
Averages	36	58	207	172	182	188	180	......

C — STEAM.

OBSERVATIONS.	Steam pressure. Lbs.	Outside temperature.	House temperature.	Thermometer No. 1.	Thermometer No. 2.	Thermometer No. 3.	Thermometer No. 4.	Thermometer No. 5.	Average thermometer readings.
December 26, 5.00 p. m.	0	18	60	208	185	190	195	187	193
December 27, 8.00 a. m.	0	18	46	210	207	208	208	169	200
December 27, 5.00 p. m.	2	30	60	220	217	219	219	179	210
December 28, 8.00 a. m.	1½	34	54	219	215	216	218	168	207
December 28, 5.00 p. m.	0	44	62	208	197	198	207	180	198
December 29, 9.00 a. m.	1	40	62	214	211	212	214	183	206
December 29, 5.00 p. m.	0	34	60	213	209	210	212	176	204
December 30, 8.00 a. m.	1	24	62	215	211	212	214	185	207
December 30, 5.00 p. m.	3½	24	62	224	222	223	223	177	213
January 2, 8.00 a. m.	2	29	58	230	230	229	229	190	221
January 3, 8.00 a. m.	0	38	60	212	208	210	212	180	204
January 4, 7.30 a. m.	0	42	54	207	....	65	56	180	127
January 4, 5.00 p. m.	0	62	70	213	212	208	212	184	204
January 5, 8.45 a. m.	0	40	62	212	192	206	196	176	196
January 5, 5.00 p. m.	0	32	59	215	185	215	210	178	200
January 6, 8.00 a. m.	0	28	59	208	....	145	205	179	184
January 6, 5.00 p. m.	0	31	56	210	208	205	209	180	202
January 7, 9.00 a. m.	0	30	60	202	110	108	110	84	122
January 8, 8.00 a. m.	0	31	52	213	180	207	212	180	198
January 8, 5.00 p. m.	½	28	60	212	198	209	211	158	197
January 9, 8.00 a. m.	1	18	56	216	200	211	215	170	202
January 9, 5.00 p. m.	½	26	58	214	201	211	212	168	201
January 10, 8.00 a. m.	0	26	50	208	180	195	206	178	192
January 10, 5.00 p. m.	0	31	52	207	85	87	89	168	127
January 11, 8.00 a. m.	0	29	54	211	186	206	211	179	198

C — STEAM — (*Concluded*).

OBSERVATIONS.	Steam pressure. Lbs.	Outside temperature.	House temperature.	Thermometer No. 1.	Thermometer No. 2.	Thermometer No. 3.	Thermometer No. 4.	Thermometer No. 5.	Average thermometer readings.
January 11, 5.00 p. m.	0	38	60	208	160	195	205	178	189
January 12, 8.30 p. m.	0	18	53	212	203	208	211	180	202
January 12, 5.00 p. m.	2½	18	54	222	211	216	220	180	209
January 13, 8.00 a. m.	0	16	60	212	200	209	211	172	200
January 13, 5.00 p. m.	0	28	62	214	205	210	210	178	203
January 14, 9.50 a. m.	0	44	60	205	198	202	204	168	195
January 14, 5.00 p. m.	1½	50	70	215	214	210	212	180	206
January 15, 8.00 a. m.	0	40	64	214	203	210	213	181	205
Averages	....	31	55	212	194	195	199	174	......

It will be seen from table A that three distinct tests, of various duration, were made with the low tank or low pressure, and from B that three short tests were made with high pressure. In drawing conclusions from all the tables, the temperatures of the house should be discarded, and the efficiency of the different trials should be deducted from the temperatures of the pipes as shown by thermometers 1, 2, 3, 4 and 5. This is because the temperature of the house was kept as uniform as possible by ventilation, so that as the heat rose in the pipes, when steam or water under greater pressure was used, the ventilators were opened wider.

By making a general total average of the various pipe temperatures in the three systems, A, B, and C, we have the following figures:

D. SUMMARY OF THE AVERAGE TEMPERATURES IN THE VARIOUS THERMOMETERS.

	1	2	3	4	5
Water, Low Tank.					
Test 1	190	159	157	146	157
Test 2	185	166	163	162	154
Test 3	189	152	150	163	155
Test 4	199	170	176	173	169
Average	191°	162°	161°	111°	159°
Water, High Tank.					
Test 1	194	175	166	180	169
Test 2	197	175	174	176	166
Test 3	207	172	182	188	180
Average	199°	174°	174°	181°	172°
Steam.					
Average	212°	194°	195°	199°	174°

It is seen at once that the lowest average efficiency is in the lower pressure water system, the next best is with the high tank, while the highest is with steam. That is, the higher the expansion tank above the heater, within reasonable limits, the hotter the water becomes because it is under greater pressure. This increase of heat was observed in all parts of the system, as shown by the uniformly higher averages in the five several thermometers. The system was also more easy to run, the circulation was more uniform in all the pipes, and its general efficiency was seen to be greater by the workmen who had charge of it. With the greater elasticity and less friction of steam, however, the efficiency is still greater, as shown in the summary figures (D). From these considerations we include that

10. *In heating by water in closed circuits, a high expansion tank may increase the efficiency by allowing the water to become hotter throughout the system, and giving a better circulation.*

If we were to compare the fluctuations, or up and down temperatures, in the various systems, by a study of the average thermometer readings in all the pipes — as shown in the last column in the tables—we should find the following:

E. EXTREME AVERAGE FLUCTUATIONS.

Water, low tank	123°	201°
Water, high tank	162°	201°
Steam	122°	221°

The steadiest temperature was maintained in the water under the greater pressure, whilst the greatest fluctuations were with steam. This poor showing of the steam, however, is mostly the result of the unadaptability of the apparatus to steam heating. In our first tests, the fluctuations were greater with water, whilst in the second, when this small heater was used, they were about the same with steam and water.

Now, the total warming power of the different systems is determined by the average temperatures of the pipes and the amount of fuel consumed. In this test we used 100 lbs. of hard coal daily in each of the three series of tests; and inasmuch as this fuel gave more heat when applied to steam than when applied to water in the same apparatus, we must conclude that under these conditions, now repeated for two winters and with the initial advantage in favor of water, steam was the more efficient and economical. If, however, more piping had been added when water was used, the final results might have been in favor of water, particularly of the greater pressure.

Illuminating gas as fuel.—Common illuminating gas is much used for fuel in small stoves, water heaters, and the like. It seemed that it might be used to advantage in heating small conservatories attached to dwellings, because it is difficult to secure a very small circulator which has a fire-pot big enough to hold a bright fire all night. I accordingly put a Perfection Water Heater (made by the Milwaukee Gas Stove Co.) in my cellar to heat a small conservatory which is 10x17 and 12 feet high. This was connected with the city gas system. Including the connections in the cellar (40 ft.), this little heater was expected to heat 220 linear feet of inch pipe with hot water. A steam heater is not practicable for such a small area.

The gas was first lighted one December day when the pipes were cold. An hour was required to thoroughly warm up the system. In ordinary snug winter weather (thermometer outside 10° to 15°), the apparatus consumed one-half cubic foot of gas per minute to keep the house at a proper temperature for conservatory plants. The system worked perfectly. Not one thing more could be desired—except cheaper gas. A very slight increase in the amount of gas—supplied by simply turning a valve—was sufficient to make a very rapid change in the temperatures of the pipes, so perfectly was the system under the control of the heater. So long as the weather was running nearly uniform, the heater demanded no thought or attention. It is the perfection of a lazy man's machine. The readiness with which the system responded to more or less gas may be indicated by the following test. When the experiment began the apparatus was consuming one cubic foot of gas every 2¾ minutes. Thermometer No. 1, on the outside of the riser at its highest point 58 feet from the heater, registered 94° and thermometer No. 2 on a return 70 feet from the heater, registered 68°. Gas was turned on until a cubic foot was consumed every 1½ minutes. The temperatures went up as follows:

	Thermometer 1, degrees	Thermometer 2, degrees.
7 minutes later	95	68
10 minutes later	98	68
14 minutes later	100	68
20 minutes later	101	70
25 minutes later	103	72
31 minutes later	105	74
40 minutes later	106	76
45 minutes later	108	77
60 minutes later	110	79
75 minutes later	111	80
85 minutes later	112	80
97 minutes later	113	80

The average gas consumption for the few days of the test, as charged by the gas company, was 650 cubic feet per day. At the price we paid for gas, the expense of running the heater was prohibitive, and it was given up with much reluctance.

LETTUCE.

Lettuce is the most popular and the most uniformily profitable of all vegetable crops grown under glass in this country. It grows rapidly, so that three crops can be taken from a house between September and April, and the demand for a choice product is always good. Lettuce is generally considered to be an easy crop to grow under glass, and yet it is a fact that few gardeners are entirely successful with the crop, year by year, particularly if the heading varieties are grown.

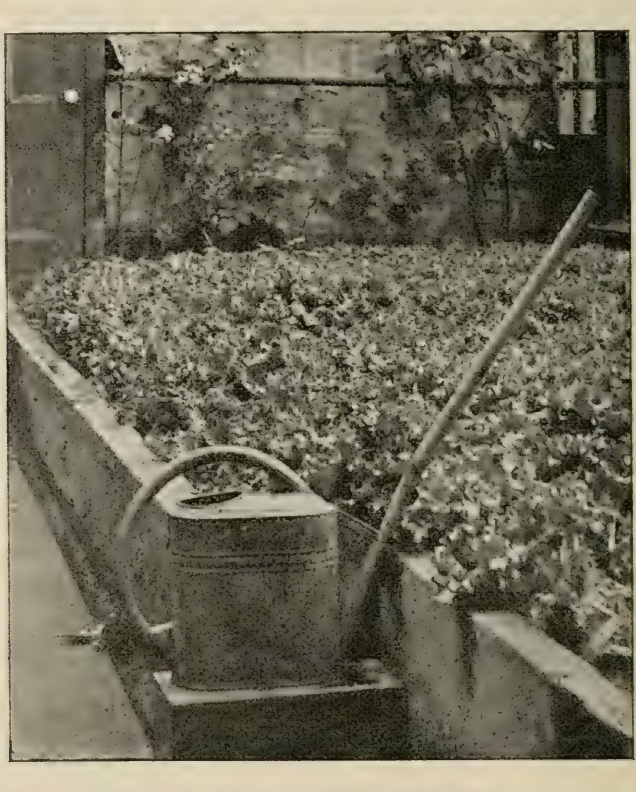
Lettuce varies greatly in quality, and this variation is due in very great measure to the immediate conditions under which it is grown. If the plant is very rank and has dark green thick leaves, the quality is low. A good lettuce plant is yellowish green in color upon delivery, and the leaves are thin and brittle. The product should be wholly free from lice, or green-fly, and the tips of the leaves should show no tendency to wither or to turn brown. If heading lettuce is grown, the leaves should roll inward like cabbage leaves, the heads should be compact and nearly globular and yellowish white toward the core.

It is not my purpose to enter into a full account of lettuce forcing at this time; I desire only to suggest a few of the most important points in the cultivation of the crop, as they have presented themselves to me during the past few years.

In the first place, lettuce must have a low temperature. The night temperature should not rise above 45°, while it may go as low as 40° or even lower. The day temperature, in the shade, should be 55° to 65°. Lettuce which is kept too warm grows too tall, and the leaves are thin and flabby; and there is generally more danger of injury from aphis, rot and leaf-burn.

Whilst a lettuce house must have an abundance of light, the plants do not suffer if they are some distance from the glass and even if they receive little direct sunlight. The house should have an exposure toward the sun and the framework ought to be as light as possible, if the best results are to be obtained; but diffused light is quite as good as the direct burning rays of the sun. It should be said, however, that good lettuce may often be grown in heavy rather dark houses, but more care is required, the results are less certain, and there is special difficulty in growing the heading varieties to perfection.

Our own experience has fully demonstrated the superiority of solid earth beds over benches, for lettuce. We have had good crops in benches, but they have required special attention to heating and watering, and even then the results are generally precarious. If, however, the benches have no bottom heat — that is, if there are no heating pipes close under them and if the sides are open — very good results, particularly with the non-heading sorts, may be had from year to year. Fig. 68 shows an earth bed, about nine inches deep, in which we have had excellent success with lettuce.



68.—A ground bed, with Grand Rapids lettuce.

When pressed for room, we sometimes prick off the plants into 3-inch or 4-inch pots and set these pots in unoccupied places amongst other plants. Very good lettuce can be grown in this way, although it is scarcely practicable in commercial houses.

Probably no forced vegetable is so much influenced by soil as the lettuce, and no doubt more failures are to be ascribed to uncongenial soil than to any other single cause. Fortunately this matter has been made the subject of a most admirable study by Galloway,* who finds that the famous heading lettuce of the Boston gardeners can be grown to perfection only in soils which contain much sand and very little clay and silt. These soils allow the water to settle deeply into it and yet holds it without percolation; the surface is dry, preventing the occurrence of rot; the roots forage far and wide, and the plant food is quickly available. The full characters of the soil used by the Boston growers are set forth as follows by Galloway: "Loose at all times, regardless of treatment, it being possible to push the arm into it to a depth of 20 inches or more. Never 'puddles' when worked, no matter how wet. Clods or lumps never form. A 4-inch dressing of fresh manure when spaded in to a depth of 15 to 20 inches will be completely disintegrated in six or eight weeks. Sufficient water may be added the first of September, when the first crop is started, to carry through two crops and a part of a third without additional applications, except very light ones merely to keep the leaves moist and to induce a movement of the moisture at the bottom of the bed toward the top, where it will come in contact with most of the roots. The surface to the depth of an inch dries out quickly, and this has an important bearing on the prevention of wet rot of the lower leaves. The active working roots of the plants are found in abundance throughout the entire depth of soil, even if this exceeds 30 inches."

Galloway was able to prepare soil which "gave practically the same results" as that which he imported from Boston. The soil was made as follows: "Mixture of two parts of drift sand and one part of greenhouse soil. The sand was obtained from the valley of a stream near by, which frequently overflowed its banks, flooding the spot where the material was found. The greenhouse soil was a mixture consisting of one part of the ordinary clay, gneiss soil of the region, and two parts of well-rotted manure. Such soil will grow 20 bushels of wheat to the acre without fertilization."

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* B. T. Galloway, The Growth of Lettuce as Affected by the Physical Properties of the Soil," Agric. Science, viii. 302 (1894).

It is always essential to the best lettuce growing to avoid "heavy" soils. These soils usually lose their water quickly, necessitating frequent watering which keeps the surface wet and increases danger from damping off and rot. These soils soon become hard, compact and "dead," and the plants grow slowly, with thick tough leaves.

If the lettuce crop is to be taken off in early November, from seven to ten weeks should be counted from the sowing of the seeds to the delivery of the product. A midwinter crop may require two to four weeks longer. The time may be shortened ten days to two weeks by the use of the electric arc light hung directly above the house. A single ordinary street lamp of 2,000 normal candle power, will be sufficient for a house twenty feet or more wide and seventy-five feet long, if it is so hung that the house is uniformly lighted throughout. Our experiments with the electric light, now extended over a period of five years, have uniformly and unequivocally given these beneficial results with lettuce.*

The first sowing for house lettuce is usually made about the first of September and the crop should be off in November. We sow the seeds in flats or shallow boxes, preferably prick off the young plants about four inches apart into other flats when they are about two weeks old, and transplant them into the beds, about eight to ten inches apart each way, when they are about five weeks from the seed. We often omit the pricking off into other flats simply thinning out the plants where they stand and transferring them from the original flat directly to the bed; but better and quicker results are usually secured if the extra handling is given. Four or six weeks after the first seed is sown another sowing is made in flats for the purpose of taking the place of the first crop. Following are some actual sample dates of good and bad lettuce growing in our houses, in a climate which is unusually cloudy and "slow" in winter: Landreth Forcing lettuce sown in flats February 24th; transplated to beds, March 17th; first heads marketed under normal conditions, May 10th; first heads marketed from a compartment receiving electric light at night (a total of 84 hours),

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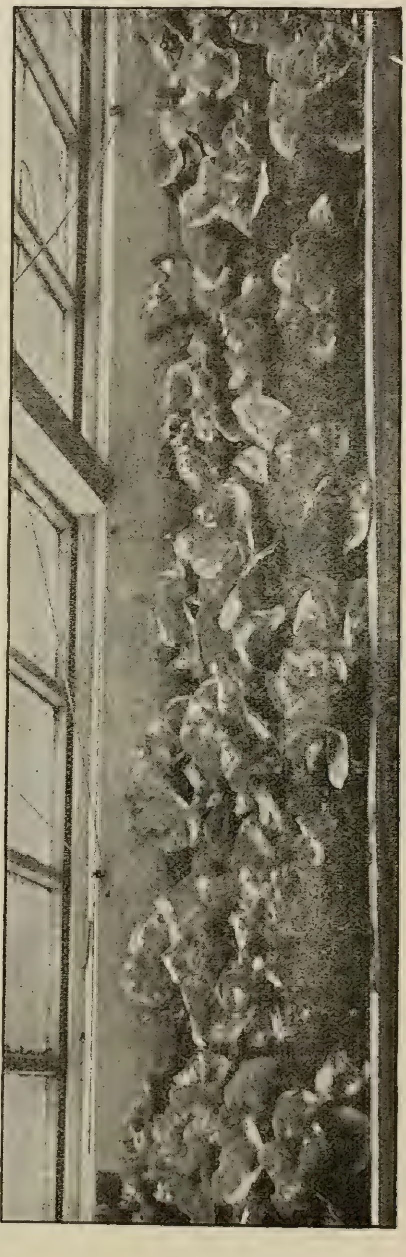
*See our bulletins 30, 42 and 55.

April 30th, or 44 days from seed. Simpson curled was sown October 3d. November 7th, transplanted to bed. It was desired to hold the crop back, so that the house was kept very cold; and the variety is not well adapted to quick forcing, so that it was January 30th, before the entire crop was fit for market, making 119 days from seed. Grand Rapids lettuce sown December 28th; transplanted to bed, January 16th; began marketing March 21st. This makes 72 days from seed, in the dark months; and at least a week could have been gained if we had not been obliged to delay transplanting whilst waiting for a crop of chrysanthemums to come off the bed.

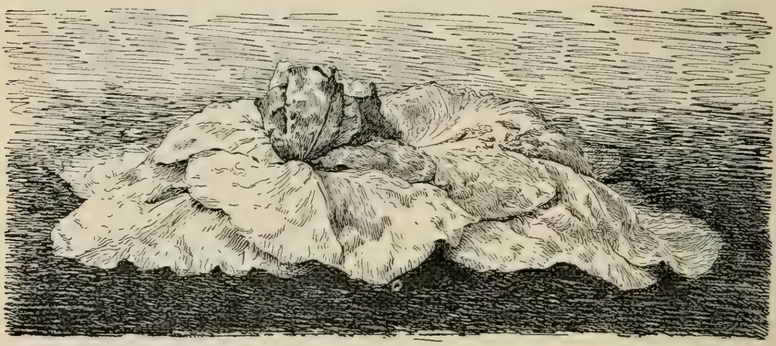


69.—Landreth Forcing lettuce, two-thirds grown.

The varieties of forcing lettuce are many, but the leading ones at present are the Boston Market or White-Seeded Tennis Ball, and Grand Rapids. The former is the famous heading lettuce of eastern markets. It is usually a difficult variety to grow to perfection unless the soil and conditions are well adapted to it. Another excellent lettuce of this type is Landreth Forcing, shown two-thirds grown in Fig. 69. The Grand Rapids is a loose-leaved lettuce, shown full grown in Fig. 68. It grows rapidly and is of very easy cultivation.

The most inveterate pest of the lettuce grower is the green-fly or aphis. If it once gets thoroughly established, the most strenuous efforts are needed to dislodge it. The pest is most frequent in houses that are kept too warm. The plants may be sprinkled with tobacco dust, or tobacco stems may be strewn upon the ground between the plants and in the walks, and either treatment may be expected to keep down the aphis. It can easily be kept out of the houses by fumigating *twice a week* with tobacco. (See page 408). *Do not wait until the insect appears.* Begin fumigating as soon as the plants are first pricked off and continue until within two or three weeks of harvest or longer if necessary.

The rot often ruins crops of lettuce. The outer leaves decay, often quickly, and fall flat upon the ground, leaving the central core of the plant standing. Fig. 70 is a fair sample of a whole bench of lettuce which we lost a few years ago from the rot. The plants were about two-thirds grown and in good condition. The house was rather over-piped for lettuce and we kept it cool by careful attention to ventilation. It became necessary for the assistant horticulturist and myself to be absent three days in mid-winter. Careful instructions were given a workman concerning the management of the house, but he kept it too close and too wet and at the end of the three days the crop was past recovery.

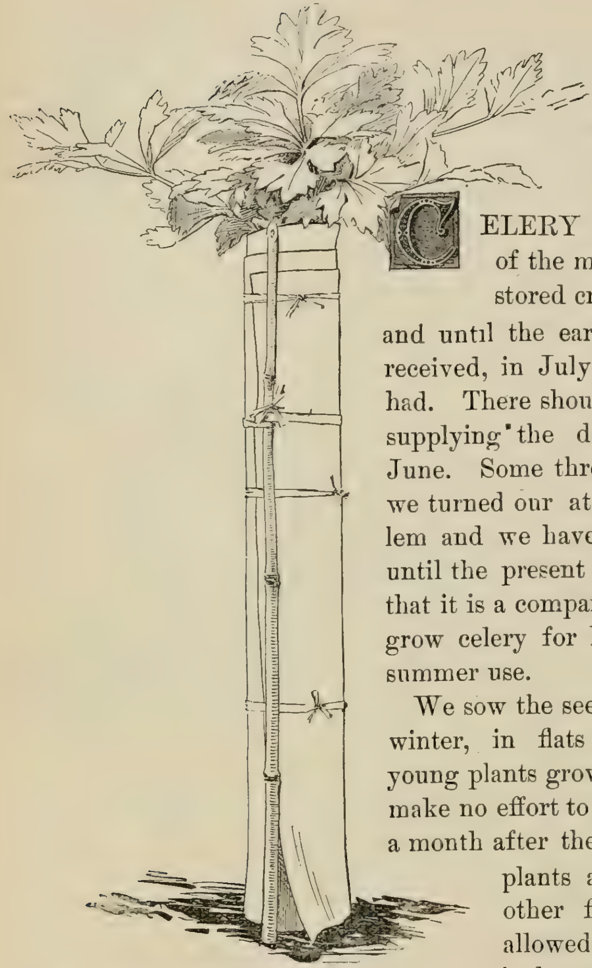


70.—Lettuce plant collapsed by the rot (*Boltrytis vulgaris*).

This lettuce rot is due to a fungus (*Botrytis vulgaris*) which lives upon decaying matter on the soil, but when the house is kept too warm and damp, and the lettuce becomes flabby, it invades the plant and causes irreparable ruin. There is no remedy, but if the soil is sandy and "sweet" and the house properly managed as to moisture and temperature, and top dressings of manure are avoided, the disease need not be feared. Galloway speaks of it as follows, in the article already quoted: "Wet rot of the lower leaves and rotting of the stems and consequent wilting of the plant are seldom troublesome in this [Boston or sandy] soil if properly handled, because the surface is at all times comparatively dry. Wet rot is produced by a fungus which may be found at any time on pieces of sticks and straws scattered through the soil. The fungus does not have the power of breaking down the uninjured tissues of the plant, excepting possibly in very rare cases. When the tissues become water-soaked, however, as they do when in contact with wet soil, the fungus, which is also most active in the presence of moisture, readily gains entrance and soon develops sufficient energy to become an active parasite."

The mildew (*Peronospora gangliformis*) is the staple lettuce disease of the books, but we have never had experience with it. No doubt much of the trouble ascribed to mildew is really the rot.

Leaf-burn is a dying of the tips of the leaves when the plant is nearly or quite mature. It is particularly troublesome on the heading varieties, in which the slightest blemish upon the leaves detracts greatly from the selling qualities of the lettuce. This difficulty, according to Galloway, is attributable largely to the soil: "Top burn, one of the worst troubles of the lettuce grower, does comparatively little injury on this Boston soil, providing the proper attention is given to ventilation and the management of the water and heat. Burn is the direct result of the collapse and death of the cells composing the edges of the leaves. It is most likely to occur just as the plant begins to head and may be induced by a number of causes. The trouble is most likely to result on a bright day following several days of cloudy, wet weather. During cloudy weather in winter the air in a greenhouse is practically saturated, and in consequence there is comparatively little transpiration on the part of the leaves. The cells, therefore, become excessively turgid and are probably weakened by the presence of organic acids. When the sun suddenly appears, as it often does after a cloudy spell in winter, there is an immediate, rapid rise in temperature and a diminution of the amount of moisture in the air in the greenhouse. Under these conditions the plant readily gives off water and if the loss is greater than the roots can supply the tissues first wilt, then collapse and die. The ability of the roots to supply the moisture is affected by the temperature of the soil, the movement of water in the latter, and the presence or absence of salts in solution. In this soil the temperature rises rapidly as soon as the air in the greenhouse becomes warm, and the roots in consequence immediately begin the work of supplying the leaves with water. The movement of the water in the soil is also rapid, so that the plant is able to utilize it rapidly."



71. Winter grown celery a-bleaching.

CELERY UNDER GLASS.

CELERY practically goes out of the market in April. The stored crop is then exhausted, and until the earliest field product received, in July, celery is not to be had. There should be some means of supplying the demand in May and June. Some three or four years ago, we turned our attention to this problem and we have been working at it until the present time. We now feel that it is a comparatively easy matter to grow celery for late spring and early summer use.

We sow the seed in late fall or early winter, in flats or seed-pans. The young plants grow very slowly, and we make no effort to hasten them. About a month after the seeds are sown, the plants are pricked out into other flats, where they are allowed to stand three or four inches apart each way. A month or so later, they are transplanted into beds, following lettuce cauliflower, chrysanthemums or other crops. It will thus be seen that for two months or more the plants take up little or no room, for the flats are placed in vacant places here and there throughout the house; and they need little other care than watering. They should be kept cool—in a house used for lettuce, violets, carnations, and the like—for if one attempts to force them they will likely run to seed. When the plants are finally transplanted, we like to put them in solid beds without bottom heat.

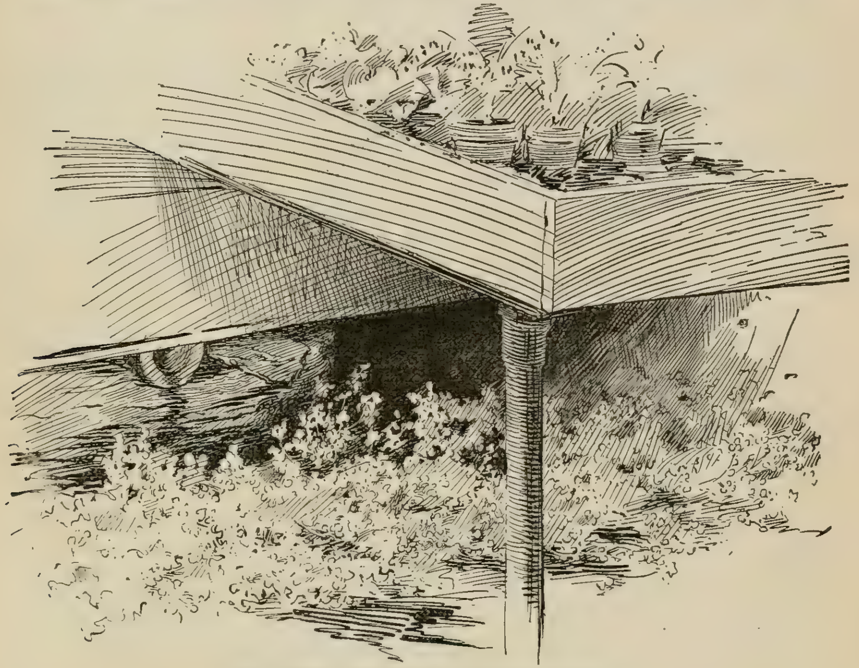
In six weeks to two months after the plants are turned into their permanent quarters, they will be ready to bleach, and this operation has caused us more trouble than all other difficulties combined. Our first thought was to set the plants very close together so that they would bleach themselves, after the manner of the "New Celery Culture," but it would not work. The plants ran too much to foliage and they tended to damp-off or rot where they were too close. We next tried darkening the house, but without success. We then attempted to bleach the plants by partially burying them in sand in a cellar, but this also failed. Finally, we tried various methods of tying up or enclosing each midwinter plant as it stood in the bed. Tiles placed about the plants—which are so successful in the field—rotted the plants in the moist air of the forcing-house. Heavy bibulous paper did the same. But thick, hard wrapping paper, with an almost "sized" surface, proved to be an admirable success. The stalks were brought together and tied, and a width of paper reaching to within two or three inches of the tips of the leaves, was rolled tightly about the plant. As the plant grew, another width of paper was rolled about the first, and again reaching nearly the top of the plant. Two applications of the paper are sufficient. A month to six weeks is required to bleach the celery by this process in a cool house in April and May. Fig. 71 shows the method of bleaching with the paper.

The seeds for our last crop of house celery were sown December 10, 1894; picked off January 8th; planted in beds, February 6th; first tied up in paper, April 12th; second tying, May 9th; celery fit to use, May 21st to June 20th. The Kalamazoo celery is well adapted to house cultivation. The quality of this house-grown product is equal to that grown in the field.

CRESS IN WINTER.

Persons who are fond of water-cress should know that no plant is easier to grow under benches in greenhouses. If there is an earth floor under the benches of a cool or intermediate house, the plant will take care of itself when once introduced, provided, of course, there is sufficient moisture. Fig. 72 shows a mat of water-cress growing under a bench in a general conservatory house, near the overflow of a tank. It is not necessary to supply water in which the plant may grow, but it thrives well, with its characteristic flavor, in soil which is simply uniformly moist and cool. The plants may be gathered from brooks or other places where it is established and planted at intervals under either north or south benches, and when once colonized it needs no renewing.

The ordinary French or garden cress (varieties of *Lepidium sativum*) also thrives well under glass. We have grown both the plain and curled-leaved forms upon benches or beds along with lettuce and spinage. The seed is sown directly where the plants are to stand. The plant grows quickly, and the early tender leaves should be used before it runs to seed.



72.—Water-cress under a greenhouse bench.

FORCING EGG-PLANTS.*

The possibility of forcing egg-plants successfully was suggested by a crop which was grown under glass in one of the market gardens near Boston in the spring of 1891. These plants were not grown with the intention of forcing them; but as the greenhouse was vacant at the time the main crop of egg-plants was set out of doors, it was filled with plants taken from the same lot as those set in the open. The beds in which they were planted were solid, that is, the prepared soil rested upon the natural surface of the ground, forming a layer from 12 to 15 inches in depth. During the preceding winter those beds had served for growing lettuce, and they had consequently been well enriched with stable manure, a fertilizer which is especially effective in the production of rapid growth. In July, when the plants grown under glass were compared with those planted in the open ground, an astonishing difference could be observed. Those set in the house were fully twice as large as the others; the leaves were larger and the stems thicker than those generally found in the gardens of this latitude, and the abundance of healthy foliage was ample proof that the plants were subjected to conditions extremely favorable to their growth.

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*Bulletin 26 contains an account of egg-plants in the field.

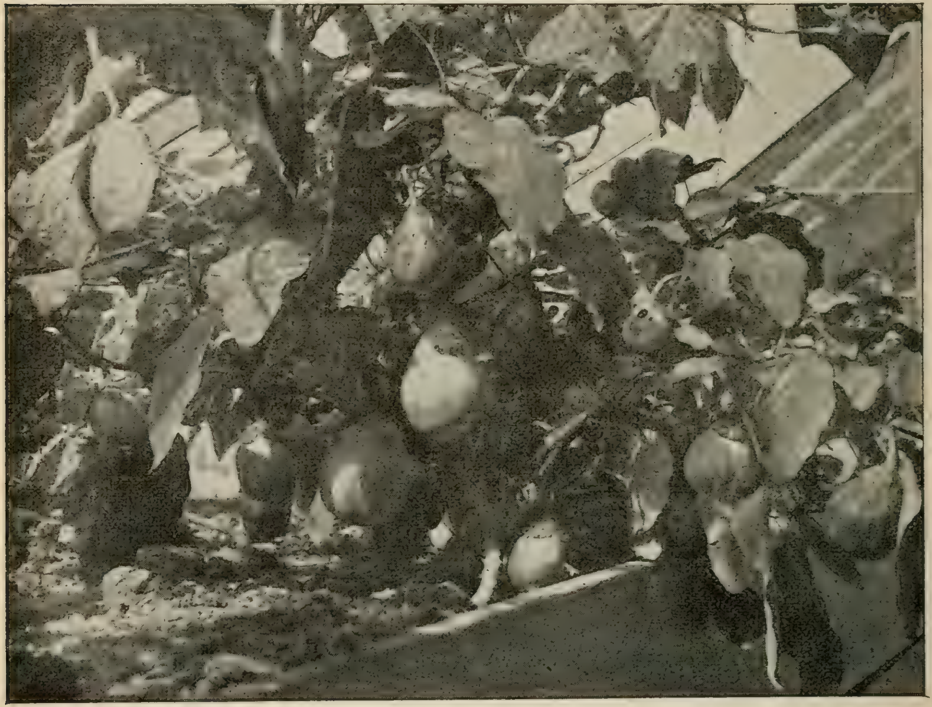
Another interesting point was soon noticed. Although the plants were blossoming quite freely, still comparatively little fruit had set, and it appeared as if the entire energies of the plants had been directed towards the production of foliage at the expense of the fruit. This condition may perhaps be ascribed to two causes. Extreme activity of the vegetative functions of plants is frequently carried on at the expense of fruit production; this fact is commonly illustrated by young fruit trees, which blossom sometimes several years before they set fruit. The growth of the egg-plants mentioned above was sufficiently luxuriant to suggest the possibility of its having some effect upon the fruiting powers of the plants. The second and perhaps most probable cause of this unsatisfactory fruiting may have been imperfect pollination. Insects, and especially bees, were not working so freely in the house as outside, and later experience has shown very clearly that in order to get a satisfactory crop from egg plants grown under glass thorough pollination must be practiced. The foliage was so dense that the flowers were for the most part hidden. In such a position they were necessarily surrounded by a comparatively damp atmosphere, especially when borne upon branches that were near the surface of the soil, and this would still further tend to interfere with the free transfer of pollen by any natural agencies. Under such conditions a profitable yield could scarcely be expected; yet when carefully observed the plants proved to be so full of suggestions regarding the proper methods of treating them that they should have repaid the time given to their culture by a plentiful harvest of ideas, if not of fruits.

Acting on the above hints several attempts have been made to grow egg-plants in our forcing houses, with the object, however, of fruiting them out of season. The first lot of seed was sown August 30, 1893. It embraced the following varieties: Black Pekin, New York Improved, Early Dwarf Purple, Round Purple, and Long White. The seed was sown about three-eighths of an inch deep in rich potting soil. The flats, or shallow boxes, which contained the seed were placed in a warm house, and the after treatment was very similar to that commonly followed in the growing of tomatoes.

The seedlings required pricking out about four weeks after the seed was sown. They were set in 2½ inch pots where they remained until November 14th, when they were shifted into 4-inch pots. On December 17th, or nearly sixteen weeks from the time of seed sowing, the plants had filled these pots with roots, and they were again shifted, but this time into benches. They were set 2 feet apart each way. The soil was about 6 inches deep and different in character in each of the two benches used. One bench had been filled with a mixture of equal parts of potting soil and manure from a spent mushroom bed. This formed a very open and rich soil which appeared to be capable of producing a strong growth. The second bench received a rich, sandy loam which had previously been composted with about one-fourth its bulk of stable manure. The temperature of the house was that usually maintained in growing plants requiring a considerable amount of heat; during the night the mercury fell to 65° or 60° and in the day time it stood at 70°–75°. In the bright weather the house was still warmer.

Considerable care was exercised in watering the plants, the soil being kept somewhat dry; when grown out of doors egg-plants withstand drought so well that such a course seemed advisable when growing them under glass. As the plants increased in size the leaves shaded the soil, and an occasional thorough watering maintained an excellent condition of moisture in the bed filled with the loam. In addition, the soil was stirred with a hand weeder when necessary.

For some time, all the varieties in each bench appeared to be doing uniformly well, but the plants set in the sandy loam made a stronger growth and appeared to be more vigorous. This was especially noticeable in the Early Dwarf Purple and the New York Improved. The first bloom appeared on the former during the last week in December, and on the 3d of January, 1894, several plants showed flowers that were well opened. These were hand pollinated and they set fruit freely. On February 15th some of these fruits were 2½ inches long, the plants still growing well and producing many blossoms. It was at this time that the first flowers of Black Pekin appeared, but New York Improved had not yet produced any, although it was making a strong growth. Round Purple and Long White were making a very slow and weak growth.



73.—Early Dwarf Purple Egg-plant under glass.

Figure 73 represents a plant of Early Dwarf Purple that was photographed May 29th. It was bearing at this time 21 fruits of varying sizes and appeared to be strong enough to mature fruits from buds that were still forming. The larger fruits were fully 4 inches in diameter, and nearly 6 inches long. They were not removed as soon as grown, as should be done in order to get as large a yield as possible, and for this reason the product of the plant is the more remarkable. All the fruits did not attain the size mentioned above for the crop was too heavy for the plant to mature it properly; neither were all the plants of this variety equally prolific, although their yield in many cases closely approached that shown in the illustration. This variety proved to be by far the most promising of those grown for forcing purposes, and it appears to be capable of producing crops which rival those grown out of doors. It is also the earliest variety tested, a point which is of the greatest importance. This vegetable is slow in coming to maturity even under the most favorable circumstances. The above photograph was taken nine months from the time of sowing the seed, but a cutting of fruit might have been made fully six weeks earlier. It set fruit more freely than any other variety, and in nearly every desirable respect was superior to them.

New York Improved was a very strong grower, and produced large handsome fruits. Unfortunately, but few could be obtained from a plant, and the total yield was therefore comparatively small, only four or five maturing on the best plants. It is also considerably later than the Early Dwarf Purple.

Black Pekin, on the whole, closely resembled the preceding, especially in the manner of its growth. But it set scarcely any fruit, and that was so late that none were matured before ten months from the time of seed-sowing.

Long White proved to be a weak grower of very slender habit. It was also very late, the fruits being scarcely over two inches in length May 29th. The plants of this variety were slightly checked when young, and this may have had a certain influence in delaying the maturity of the crop, although the effect was probably not very great. One desirable feature of this variety is its smooth foliage which appeared to be unfavorable for the development and persistence of some of the insects that attack greenhouse plants. But the lateness of the variety and the few fruits produced by it will prevent it from being profitably grown under glass.

Round Purple proved to be the most unsatisfactory grower. All the plants showed symptoms of being in unfavorable quarters, and the test with this variety resulted almost in total failure.

Later attempts to force egg-plants have been made, although no duplicate of the above experiment has been planned. The crops were started later in the season when more sunlight and heat were present. These trials have thrown light upon some of the doubtful points of former experiments, and have shown what is probably the principal reason of the slow maturing of all the varieties tested, and also the very weak growth of some.

One of the results obtained is of especial interest in this connection. Some Early Dwarf Purple plants were started early in August and some of the seedlings were grown in houses in which different degrees of temperature were maintained. The plants grown in an intermediate or moderately warm house made but little growth, and were soon stunted and worthless. This showed conclusively that egg-plants require a high temperature for their rapid and vigorous development. Other plants were placed in each of two warm houses, one of which was shaded by means of a thin coat of whitewash upon the glass: The plants in the other house were exposed to direct sunlight and they were also subjected to a bottom heat of scarcely five degrees. Although the air temperature of the two houses was practically identical, the plants receiving the sunlight grew fully twice as fast as the others and had open blossoms before those in the shaded house showed any buds. When some of the latter were removed into the same favored position they very soon showed a benefit from the change. In this way the plants themselves emphasized the necessity of plenty of sunshine for their development in winter quarters; and a certain amount of bottom heat, from 4 to 6 degrees, is also very beneficial, the air temperature at the same time being that of a warm house.

Egg-plants designed for forcing should never be stunted. An important aid to prevent this condition is a soil which is open and still rich in available nitrogen. A rich, sandy loam, in which all the ingredients are well rotted, is preferable to one having the manure in an undecayed condition. The latter is too open, and it is more difficult to maintain a proper supply of moisture. The soil should be sufficiently open to afford good drainage, but not so coarse that it dries out too rapidly. The bench mentioned at the beginning of the article as containing manure from a spent mushroom bed did not prove so satisfactory as the one containing the sandy loam, largely because it was more difficult to manage.

Another point which should not be overlooked in forcing egg-plants is the pollination of the flowers. This is most satisfactorily done by hand, the small number of insects found in greenhouses during the colder months being of very little use in this respect. The work can be done rapidly by means of a small flat piece of metal, such as can be made by flattening the point of a pin with a hammer and then inserting the other end into a small stick, which will serve as a handle. Such a spatula is also very convenient in nearly all kinds of pollination made by hand, as it is so readily kept clean of foreign pollen. Figure 74 represents a flower of an egg-plant. In the center will be seen the stigma which projects beyond the tips of the ring of anthers or pollen-bearing organs which surround it. If an anther is separated and closely examined it will be seen that there are too small openings at the tip; it is through these that the pollen normally escapes. But this escape does not take place freely until the flower has matured to such an extent that the tips of the anthers stand erect and recede from the stigma, leaving the latter standing unsupported. The pollen can be most rapidly gathered upon the spatula by inserting the point of the metal into the side of the anther and opening it by an upward movement of the instrument. In this manner a large quantity of pollen may be gathered very rapidly, and it is the work of but an instant to press it upon the end of the stigma. One such treatment, if performed when the surface of the stigma is adhesive, is sufficient for each blossom.

74.—Flower of Egg-plant.

Egg-plants are subject to the attacks of all the common greenhouse pests, but if care is exercised from the beginning no serious damage need be feared. Green-fly is easily overcome by tobacco smoke, as described on page 408, while mealy bug can be overcome by well directed streams of water. The foliage of egg-plants is not easily injured by such applications of water, and the insects may be dislodged with impunity as often as they appear. The worst pests of egg-plant foliage are the red spider and his near relative, the mite. The latter is especially difficult to treat, as it is not so much affected by moisture as is the red spider, and for this reason it can not be so readily overcome. The rough foliage of the egg-plant is especially well adapted to the lodgement of these mites, and when they have once become established their extermination is practically impossible. Too much care, therefore, can not be taken in watching for the first appearance of these scourges, and in destroying them as soon as discovered. It is well to apply water freely to the foliage, even before the insects appear, for the leaves do not immediately show their presence and such applications will do no harm. The Long White does not suffer from these insects so much as the other varieties, since it has comparatively smooth leaves, which do not afford a very secure retreat. Nevertheless, it will bear watching as well as the others. The water that is applied should be directed mainly toward the under surface of the leaves, as the insects are here found in the greateat abundance, and the parts are also most difficult to reach.

The returns to be derived from egg-plants grown in greenhouses can not yet be estimated, since to my knowledge no such products have ever been placed upon the market. The first fruits from the south command a good price, but whether the home-grown article will meet with such favor that it will repay the cost of the long period of growth can not be told. The experiment from a commercial standpoint is well worth trying.

WINTER PEAS.

During the past few years, peas have at various times been grown in the forcing houses at Cornell with the intention of determining their value as a commercial crop and also to study their behavior under glass. The forcing of peas has been carried on in northern Europe for many years, although on a somewhat different plan than that undertaken at this station. Foreign gardeners generally grow the winter crop in frames or hot-beds. In the neighborhood of Paris such protection is unnecessary and successive sowings are made in the open ground from November to March, one of the most popular varieties for this purpose being St. Catherine (*Pois de Sainte Catherine*). This variety is particularly adapted to late fall and early winter sowings. In more northern latitudes, either cold frames or hot-beds supply the necessary protection for maturing the crop. Ringleader, Early Dwarf Frame, and Caractacus have been very popular in England. The second named variety is especially adapted for growing in hot-beds. It is exceedingly dwarf and matures very quickly, so that considerable quantities of peas may be harvested from a small area. Taller varieties are generally bent over to admit of their proper growth.

Peas thrive in a cool temperature, and the protection afforded by comparatively little glass or wood is sufficient to carry them through moderately cold weather. In the northern states artificial heat must be given if the crop is to be grown during the winter months. As this can not be done conveniently in frames, larger structures must be employed, and these may easily be supplied with a proper amount of heat for growing this vegetable. A night temperature of 40° to 50°, and a day temperature 10° to 20° higher, will be sufficient to cause rapid growth and fairly prolific plants. Peas succeed best, as a rule, if grown in solid beds of rich, sandy soil that is well supplied with water. If peas grown under glass are subject to the above conditions, their culture presents no serious difficulties, and it will scarcely be necessary to mention the details of more than one crop which we have grown.

Seeds of two varieties of peas were sown January 6th, 1894; they were Extra Early Market, and Rural New Yorker. They were planted at the same depth as in out-door culture, but the seed was sown more thickly, and the rows were as close to each other as the after culture of the crop would allow. Very dwarf varieties, such as Tom Thumb and American Wonder, may be planted in rows 3 to 5 inches apart, depending on the richness of the soil and the general care given the plants. Tall growing varieties, as Champion of England, may be sown in rows running in pairs, the distance between the rows of each pair being from 6 to 10 inches, while the pairs are separated by spaces 15 to 18 inches wide. This will allow working room among the plants and still admit of heavy planting.

One of the essential points in the successful growing of peas, whether in a greenhouse or out of doors, is the use of fresh seed. Garden peas retain their vitality from three to eight years, but the shorter period may be considered as more nearly correct when applied to varieties which are to be forced, since the loss of a week or two under glass is expensive, and two sowings can not well be afforded. The seedlings began to appear eight days after seed sowing and they grew vigorously from the start. February 23d, Rural New-Yorker showed the first opened blossoms, Extra Early Market at the same time having buds which were about to open.

On the 20th of March, or about seventy-three days from sowing the seed, both varieties had matured sufficiently to supply pods that were fit for market, but no picking was made until eleven days later when the plants yielded pods at the rate of 6½ quarts for each 80 feet of double row. There was practically no difference between the two varieties as regards earliness or the amount of yield obtained. Two weeks later, a second and last picking was made, the plants yielding only-half as much as before. This brings the total yield to a little over a peck. This is scarcely a profitable crop, especially since the varieties grown are quite tall and required a trellis.

Formerly, the trellises used consisted of branches forced into the ground so that they would afford support to the vines. But with the crop here considered, a more satisfactory trellis was made by using a wire netting having large meshes. This was fastened between the rows by means of stakes, and thus each strip of netting served as a support for a double row. This forms the neatest and most substantial trellis here used for supporting the vines.

The yields from extremely dwarf varieties, such as Tom Thumb, have proved unsatisfactory. The plants require no support, but they yield only one picking and this is so light that their culture under glass can not in all cases be advised.*

Peas grown under glass are sensitive to heat, and the warm spring days, when accompanied by sunshine, check their growth to a marked degree. The most healthy growth is made during the cold months of the year, and after April 1st not much should be expected from the vines unless steps are taken to keep the house as cool as possible. This may be accomplished by shading, and by a free use of water upon the walks of the house.

From a financial standpoint, the growing of peas can scarcely be advised, but amateurs may derive much satisfaction from their culture as the plants are easily grown, they require little care, and the quality of the peas is especially appreciated when no fresh ones are on the market.

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*See Bull. 30. p. 92.

BEES IN GREENHOUSES.

Much has been written regarding the value of bees in greenhouses. It is said that all hand pollinations may be dispensed with if desired, as the bees will work among the blossoms and thus cause the fruit to set.

During November, 1893, a hive of bees was received, and on the 23d day of the month they were set free in the brightest of all the station houses (shown on page 369). The hive was placed at the south end of the house, and the bees were kept constantly supplied with proper food. At this time the house was filled with tomato plants in full bloom, and it was hoped the bees would work among them so that the tedious but very necessary hand pollination of the flowers need no longer be practiced. The bees evidently did not catch the idea, however, for if there was one place in the house which they did not visit it was the tomato blossom. They spent most of their time in bumping their heads against the glass sides and roof of the house, and at every opportunity, when the ventilators were raised a little, they took pains to pass through them, even though the mercury stood far below the freezing point out of doors. The bees which did not succeed in finding the ventilators continued to fly against the glass, leaving it only for the purpose of withdrawing far enough to get a start for a fresh attack. In this way the busy bee finally wore herself out, and, in the course of three weeks, those less ambitious individuals which did not fly heavenward in the friendless atmosphere of December, were scattered as corpses along the sides of the house close to the glass; and thus ended the attempt to make these little creatures useful in midwinter. It may be said that bees do not like tomato flowers, but our specimens took no pains to find out whether they liked them or not. It is probable that every bee in the swarm went to his honeyless bourne without ever having discovered whether the plants were tomatoes or buckwheat, or, in fact, if there were any plants at all in the house.

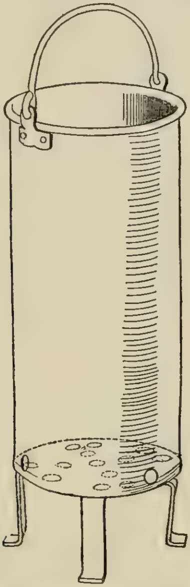
METHODS OF CONTROLLING GREENHOUSE PESTS BY FUMIGATION.

The insects and the fungi which seriously injure greenhouse plants are comparatively few in number, but if allowed to develop unchecked they are capable of entirely ruining every susceptible plant in the houses. There are some plants which are almost entirely free from such attacks, but they form isolated exceptions to a very general rule. All who have had any experience in growing plants under glass know that diseases are sure to appear and that insects will originate apparently from nothing. Indeed, so certain are these pests to appear that every thorough gardener is at all times prepared for them, or even takes steps toward their destruction before they have been seen. Fortunately, he has at his command abundant means of protecting his plants, and houses in which insects and fungi are found in large numbers are silent but convincing witnesses of bad management and neglect. When a greenhouse has once become thoroughly infested, it is almost impossible to rid the plants of their parasites, and it requires constant and prolonged attention to bring about this result; and even when this has been done, the plants will in many cases have become so weakened that they will scarcely repay the time and labor employed in saving them. The care of plants should begin before they are attacked, and this care should be given uninterruptedly. By treating apparently uninfested plants many invisible enemies may be destroyed, and such treatments are by far the most valuable ones.

Tobacco.—Several of the most common and often very serious organisms may be overcome by vapors with which a house may be filled, and the best known and the most valuable remedy of this nature is undoubtedly tobacco. The poisonous alkaloids found in the tobacco plant are fatal to many insects. The waste parts of the plants, particularly the "stems," are utilized by florists and others for purposes of fumigation.

These stems, which are almost invariably the dried mid-veins of the leaves, may be obtained for almost nothing at any cigar factory. When wanted for fumigating purposes they should not be too dry, else they will blaze, instead of slowly smouldering and forming a dense smoke. In case the stems are too dry, they may be moistened by sprinkling water upon them; a better way, however, is to store the stems in a moderately damp place, and then they are always in good condition for burning. If they blaze while the house is being fumigated, much of their value is lost, and it is also said that plants are positively injured in such cases, although our experience has not supported this view.

Tobacco stems may be burned in a variety of ways. Some gardeners merely pile the required quantity upon a brick or stone floor in the house and set fire to it by means of paper or shavings. An old coal scuttle answers the purpose very well. Figure 75 represents a tobacco-stem burner which we have designed, and which is perhaps as simple, serviceable, and easily managed as any in use. The body of the burner is made of heavy, galvanized sheet-iron. It closely resembles a stove pipe in form, but is about seven inches in diameter and two feet in length. The bottom is made of the same material; it is perforated by about a dozen holes, each three-eighths of an inch in diameter. Four legs support the burner and keep the bottom three inches from the floor. A handle at the top completes the device. When filled, the stems being packed sufficiently close to insure their burning, it contains an amount that will answer for a house of 4,000 to 6,000 cubic feet. Much, of course, depends upon the tightness of the house, and considerable variation will also be found in the strength of the stems. Occasionally some will be had which are much weaker than those last used, and hence larger quantities must be employed. It has been our practice to test each new lot of stems to determine their strength before they were freely used in all the houses. The quantity must also be varied in accordance with the plants growing in the house. Some plants are much more easily injured by the smoke than others, and the amount used



75.—Home-made Tobacco Fumigator.

must be insufficient to hurt the most tender plants. Less injury is apt to result if the houses and plants are dry; wet foliage is quite easily scorched by the smoke. Our method of starting a "smudge" is to place a single sheet of newspaper, previously lighted, in the bottom of the burner, and upon this the stems are immediately placed. If properly dampened, they will take fire readily and smoulder without blazing.

The frequency with which a house should be smoked cannot be definitely stated. Some conservatories will require the operation scarcely more than two or three times during the winter, while others may need that many treatments each week. In the latter case, it is well to have the smudges upon consecutive days, as in this manner insects receive a second treatment before they have recovered from the first. The evening is perhaps the best time for fumigating, as most of the disagreeable odor is thus escaped. But it may be advisable, in badly infested houses, to follow the evening treatment by another the next morning. In such cases, care should be exercised that the houses do not become overheated by the morning sun.

Tobacco smoke may be used successfully in the destruction of the various aphides which are found upon greenhouse plants, and of a small white fly, a species of aleyrodes. Other insects can not be practically treated by its use.

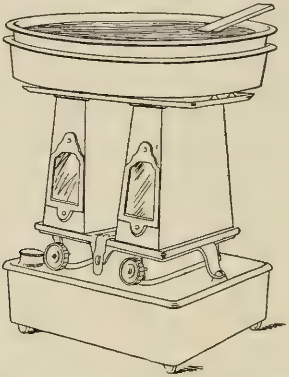
Bisulphide of carbon has recently assumed a prominent position as an effective insecticide. It is a clear, transparent liquid, which evaporates rapidly even at a low temperature. These fumes are fatal to insect as well as animal life, and it may be used to a limited extent in the greenhouse. The vapor is of greatest value in destroying a small mite (*Tetranychus bimaculatus*) that closely resembles the red spider. This mite is not as easily overcome by water as is the red spider, and in certain cases it may be advisable to resort to the bisulphide of carbon treatment. This treatment is adapted to plants which are growing in pots or to low growing plants in beds. Whole houses could scarcely be treated in this manner, as the vapor is heavy and an uneven distribution would probably result. But for small, confined spaces, as bell jars, tubs or barrels, the remedy can be used with success. I have had no difficulty in destroying mites and red spider by the use of 60 minims or drops of the liquid to a space containing about 7 cubic feet. The liquid was poured on cotton batting, which was spread over a small rose from a watering can, the stem of the funnel being set in the soil. The plants remained covered with enamel cloth nearly two hours, which sufficed to kill all the insects, and did not injure the violets, these being the plants treated.

Hydrocyanic gas— The success which has followed the use of hydrocyanic gas in the treatment of scale insects infesting the orange groves of California has suggested the idea of its possible value in destroying greenhouse pests. The common method of making the gas is as follows: One fluid ounce of sulphuric acid is added to 3 ounces of water. To this diluted acid there is then added 1 ounce of 60 per cent. cyanide of potassium. Effervesence immediately takes place, and the gas is freely given off. The quantities here given are sufficient for a space containing 150 cubic feet, the plants being exposed to the gas for 1 hour. When trees are dormant such treatment is not followed by any evil effects.

During the past spring several growing plants were exposed to the action of the gas when used according to the above directions. Tomatoes, egg-plants, oranges and roses were used. The day following the treatment showed that all the plants were injured, but to what extent could not well be determined. After two weeks had passed, however, the effect of the treatment was plainly seen. The tomato plant died; the egg-plant and the rose lost all their foliage, but fresh leaves were appearing on the stems; the orange suffered the least, since only the young leaves were affected. The mites had all been killed, so that in this respect at least the experiment was successful.

Other trials were made with the gas, using the same kinds of plants, but it was found to be impossible to destroy the mites without injuring at least some of the plants. The use of hydrocyanic gas for the destruction of greenhouse pests can, therefore, scarcely be recommended. It should also be remembered that this gas is very poisonous.

Sulphur is an element which is of the greatest service in greenhouse work. It is an invaluable agent for the destruction of mildews, and is also of great assistance in overcoming red spider. As commonly used, it is mixed with an equal bulk of air-slaked lime or some similar material, and then water, oil, milk or some other liquid is added until a thick, creamy paste is obtained. This is then painted upon the heating surfaces in the house, and the sulphur fumes are given off. The same result can be obtained much more rapidly and energetically by heating the flowers of sulphur until it melts; the fumes are then given off in great abundance. Our practice has been to put the sulphur in a shallow pan and then set it over an oil stove, having the flame turned just high enough to keep the sulphur in a melted condition. Almost continuous watching was necessary to prevent the material from taking fire, for if this should occur it would prove almost instantly fatal to all the plants which might be reached by the gas. The difficulty was in a great measure overcome by L. C. Corbett, at that time an assistant in this department, who suggested the use of a sand-bath as a means of modifying the intensity of the heat. Our present outfit is shown in Fig. 76. It consists of two pans placed on an ordinary hand oil-stove. The lower pan is half filled with clean, coarse sand, and the upper one contains the sulphur. By its proper use our houses have been kept remarkably free from mildew, even under very adverse circumstances. But there is constant danger that the sulphur will become heated to the burning point, and then the entire stock of plants in the house is lost. This use of sulphur is often very convenient, but the work should be placed in the hands of a most trustworthy person. If a house should be thoroughly treated in this manner every week or two, scarcely any mildew could develop.



76.—Apparatus for evaporating sulphur.

TREATMENT OF CARNATION RUST.

There is probably no disease of carnations which is a greater menace to their successful culture than the rust. This disease is caused by a fungus (*Uromyces caryophillinus*). It is of European origin, and was first reported in this country in 1891. On account of the rapidity with which the disease has spread, and the serious losses that follow its attacks if allowed to develop unchecked, it has been ranked among those which are treated with difficulty. It appears probable that some exaggerated statements have been made regarding its control, yet carnation growers can not be too careful in adopting all measures that may prove effective in destroying the parasite.

The disease has been rapidly introduced into all parts of the country by means of diseased stock sent out by propagators. The first item in growing a healthy lot of carnations is to have the plants free from disease when they are set in the bench. All rooted cuttings received from other growers should be closely examined, and the affected ones discarded. The same protection should be taken at the time of setting the plants in the benches. It is only in this manner that a clean start can be made, and even in spite of such care, the trouble appears only too frequently.

During 1894, some new varieties of carnations were sent us for testing, and with the plants came the rust. For obvious reasons these plants could not be discarded, and the attempt was made to grow them in a bench which was also set with carnations of standard varieties, these being entirely free from the disease.

The bench was planted during September, but no fungicide was applied until November 17. At this time the rust had spread among the healthy plants that were growing next to the affected ones, about a dozen being diseased. Some were so seriously attacked, however, that steps were taken to check the spread of the disease.

Two mixtures were applied. The first consisted of the Bordeaux mixture* to which was added soap. This addition was made in order to render the mixture more adhesive. Varying quantities of soap were tried, but the stated amount proved as satisfactory as any. The foliage of carnations is particularly difficult to wet, and much trouble was experienced in obtaining a uniform application. The soap appeared to possess a certain value in preventing the mixture from collecting in drops and rolling from the leaves, yet this action was not as marked as was desired. It was found, however, that if an extremely fine spray was made the liquid could be fairly well distributed.

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* Copper sulphate 6 pounds, quicklime 4 pounds, soap 1½ pounds, water 45 gallons.

The second mixture contained bichloride of copper and air-slaked lime.* Soap was added to this mixture for the reasons given above, and the preparation behaved in a manner very similar to that of the Bordeaux mixture.

As already stated, the first application was made November 17th; this was followed by a second on the 24th. The plants were covered as well as possible, the entire bench receiving treatment. No check plants were left, as the extermination of the disease, so far as possible, was attempted. The effects of the treatment, however, left nothing to be desired. Not only was the spread of the disease stopped, but affected plants put out new growths which remained healthy. At the time of making the applications, all parts affected with the rust were removed when possible, and this also tended to check the trouble. Still, when one considers the enormous number of spores produced by the fungus, and that these may infest healthy tissues at any time when the proper conditions of heat and moisture are present, this sudden check to the spread of the disease is very encouraging, and makes the successful control of carnation rust by the use of fungicides very probable. If, in addition to such treatment, care is exercised in selecting only healthy plants for propagating purposes, and all affected parts are removed as soon as discovered, little danger need be feared from this disease.

L. H. BAILEY.
E. G. LODEMAN.

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* Copper bichloride 2 ounces, air-slaked lime 2 ounces, soap 10 ounces, water 12 gallons.

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Cornell University—Agricultural Experiment Station.

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OF

ENTOMOGENOUS FUNGI.

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85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. On the Effect of Feeding Fat to Cows.
93. The Cigar-Case Bearer.
94. Damping Off.
95. Winter Muskmelons.
96. Forcing-House Miscellanies.
97. Entomogenous Fungi.

On account of the technical nature of this Bulletin, only a small edition is printed for the use of Experiment Stations and Exchanges.

Studies in Artificial Cultures of Entomogenous Fungi.

Most insects are subject to contagious diseases which determine to some degree the extent of the ravages of injurious species and which, at times, destroy beneficial ones. The possibility of controlling these diseases, and of introducing epidemics where they are desirable, has led several investigators to carry on researches in this direction ; and the results of some of these investigations have led their authors to believe them of considerable economic importance.

The subject has become one of general interest, and it is desirable to have as complete a knowledge as possible of the affinities and life histories of such entomogenous fungi as are capable of artificial cultivation. The object of the present paper is to determine by means of artificial cultures, the life histories and the relationship of the forms studied as well as to carry on preliminary studies respecting the practicability of introducing diseases among insects. Most of the forms studied are members of the genus *Isaria*, and its perfect form *Cordyceps ;* the others are species of the genus *Sporotrichum.*

The material from which the present study was made has been obtained from specimens collected in the vicinity of Ithaca, N. Y., or kindly sent by others. The studies in artificial media were made in the labratory of cryptogamic botany in Cornell University under the supervision of Professor G. F. Atkinson. The experiments in the infection of insects were carried on in the insectary of the Cornell Agricultural Experiment Station under the supervision of Professor J. H. Comstock.

When a study with artificial cultures is to be made, the first step is to separate the disease-producing organism from the accompanying bacteria and fungi, and to grow it in pure cultures. To do this, plate cultures are made with nutrient agar or some like preparation. In the present work, nutrient agar, the ordinary agar-agar-peptonebroth, has been used, except in one or two cases where the organism refused to grow and produce spores on this substance. In these cases potato agar, made from potato and agar only, was employed.

To separate a fungus a small portion containing spores is removed usually to a slide and teased apart in a little water. Meanwhile three tubes of agar have been placed in the water-bath and heated until the agar is melted. They are then cooled in water to 43° Centigrade, and the spores and pieces of fungus on the slide are washed into the first tube and well shaken. A drop or two is now poured into tube number two and shaken, and the process is repeated with tubes numbers two and three. It is now probable that by this repeated dilution only a few organisms have been transferred to tube number three. In separating spores of fungi this method of poring a drop from one tube to the next, is preferable to dipping in a sterilized needle as is usually done in transferring bacteria, for the spores of fungi are so much larger than bacteria that the number of fungus spores, which would cling to the needle, would be small in proportion to the number of bacteria which would also be transferred with them. By pouring out a drop, the proportion of fungus spores to the bacteria present remains unchanged. The contents of each tube is now poured into a sterilized Petrie-dish. The melted agar spreads evenly over the bottom of the dish and soon hardens into a firm, jelly-like layer, thus fixing in position any organisms present. Bacteria and spores of fungi grow freely in this layer, and the plate may be placed at any time under the microscope and the progress examined. Moreover the organism, being fixed, is obliged to confine its growth to a relatively small area. Isolated growths or colonies starting from a single organism or spore may usually be found in the second plate and often in the first. It is well to make studies from such isolated growths, for if two run together it is possible that they will contain more than one species. A small portion may now be removed on the point of a sterilized platinum needle and transferred to a stick of sterilized potato or other suitable medium. A pure culture is thus obtained. It is also sometimes possible to obtain the pure culture direct from the insect by touching a sterilized needle to the spore-bearing stroma and then to a tube of potato.

CORDYCEPS CLAVULATA (Schw.) ELLIS.*

One often finds, in moist or shady places, the remains of scale-insects belonging to the genus *Lecanium* on which are growing the delicate fruiting bodies of a small fungus. These fruiting bodies are between two and three millimeters long, and terminate in a more or less conical head about one millimeter in diameter, Fig. 97. The color is brown or black. These heads are covered with small rounded papillate projections which are the openings of flask-like conceptacles containing the reproductive bodies. The scale on which the fruiting bodies are borne is often shrunken so completely by the fungus and partially or wholly replaced by it that it appears as a lenticular base belonging to the fungus. On crushing one of these heads, one finds many sacs called asci. Each sac contains eight slender cylindrical spores which are divided by septa into about twelve or fifteen segments. This fungus is found on scales infesting various trees. Schweinitz† found it on black ash, on *Quercus palustris*, and on *Q. coccinea*. Dr. Peck found it† on *Fraxinus sambucifolia*. I have found it on *Acer pennsylvanicum*, on wild chery, on butternut, on juniper affected by *Lecanium fletcheri* and on various species of *Quercus*. The species was first described by Schweinitz.‡ Berkeley and Broome,§ afterward described in English form, *Cordyceps pistillariaeformis*, which may be the same. Dr. Peck† refers the specimens found by himself to Schweinitz's species.

On May 13th, 1895, I found a maple, *Acer pennsylvanicum*, badly infested with a scale-insect, *Lecanium* sp. Many of the scales appeared abnormally yellow, some approaching bright orange in color. On teasing one apart in water and examining it with a microscope, it was found to be teeming with small, oval or ellipsoidal, hyphal bodies, very closely resembling yeast. Some were almost fusiform. These bodies often contained one septum and the interior was partially or wholly filled with large granules of an orange color tinged with green. In some cases constrictions were to be seen in the larger bodies, and always at the point where the septum was located (Fig. 1).

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* *Technical description of Cordyceps stage.*—Sporophores slender, from 2 to 3 mm. long, bearing a conical head slightly less than 1 mm. in diameter and somewhat longer than broad. Perithecia sub-immersed and rounded, containing fusiform, eight-spored asci about 120 microns long (Fig. 11). Spores ten to twelve segmented and from 3 to 3½ microns in diameter (Fig. 12). The color is fuliginous tinged with yellowish green.

† Synopsis of N. A. Fungi, No. 1155.

‡ 28th, Rept. N. Y. State Mus., p. 70.

§ No. 969, Brit. Fungi.

A dilution culture was made on May 14th, and in two days one or more slender germ-tubes had been put out at one or both ends of the hyphal body. After five days the growth stopped. Pieces of agar, containing live and growing bodies, were removed and placed in acidified agar, but no further growth took place. On May 16th, a red cedar, *Juniperus virginiana*, was found infested with another scale, *Lecanium fletcheri*, and as some of these appeared very much like the ones on maple, they were also examined. Bodies closely resembling those in the first scale were found. They differed only in being larger and once or twice septate (Fig. 4).* A dilution culture was made and germination took place as in the first instance, with, however, a more vigorous growth. Fig. 5 shows the bodies after one day; Fig. 7 a portion of the mycelium after two days. Septa and a few small vacuoles appear about this time. Branching occurs quite profusely and irregularly. Fig. 6 shows a portion of the mycellium after five days. Many large and regularly placed vacuoles are present and the threads are constricted between the vecuoles. Small pieces of agar containing this growth were transferred to tubes of acidified agar, and some were also transferred to tubes containing potato steeped in a strong infusion of Lecaniums. Out of a large number of tubes, two showed a growth of very fine, white, cottony filaments which in time became quite dense and somewhat matted. On examination this growth is found to consist of long, fine filaments bearing, at irregular intervals, flask-shaped sterigmata placed at right angles to the parent thread, and which taper to a fine point and bear usually one oval or ovate conidium from 3 to 4 microns in size. The thread is filled with hyaline protoplasm containing small granules (Fig. 9). Sometimes there is a short side branch from the tip of the sterigma which bears a second spore (Fig. 9). From these cultures conidia were transferred to tubes containing sterilized sticks of elm covered with coccids. A vigorous growth was in this way obtained. About this

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*Since that time, specimens identical with these have been found on maple and specimens similar to the ones first found were also seen in *L. fletcheri*. It seems almost certain that the two forms are specifically one, as intergrading forms are present in both cases.

time a coccid was torn apart and examined. It was seen to be full of hyphal bodies like those first found, but somewhat swollen and producing nearly straight germ tubes (Fig. 3). A little later coccids were found having a white fringe around them, and bearing on the back small white projections like the beginnings of sphorophores, composed of many threads growing together and producing a solid mass. This is the beginning of the Isaria-stage. On examining the fringe a condition of affairs similar to that found in the cultures was observed, the flask-shaped sterigmata and conidia exactly resembling those seen in the cultures. On keeping these coccids in a moist chamber for a few days a dense white, cottony growth similar to that produced in the cultures appeared, covering the scale. Somewhat later a reddish powder was seen borne directly on the coccid. This proved to be made of bodies similar to the hyphal bodies (Figs. 1 and 4). I was unable to observe the manner in which they were borne, and have been unable to produce this stage since. The short sporophores mentioned as the beginning of the Isaria-stage continued to grow, and on examination were seen to be made up, at first, of loose fibres which unite to form a slender white sporophore bearing sterigmata and conidia resembling those in the fringe and in the cultures. Fig. 98 shows a number of coccids at this stage.*

The cultures on sterilized scales afterward produced sporophores of the true Isaria type, about 3 mm. in length and ½ mm. in diameter. They resembled in every way the sporophores found on scales growing under natural conditions. After nearly 7 months transfers were made from these cultures to sticks of potato and pure cultures obtained. When growing under natural conditions, the apex of the Isaria-sporophores becomes enlarged and assumes the form of a conical head, bearing closely packed rounded perithecial which contain many asci about 120 microns in length and 13 in diameter. They are fusiform and taper to a slender base. At the apex the spores do not entirely fill out the ascus, leaving the appearance of a small hyaline cap, formed by the membrane of the ascus. The asci contain 8 spores, which are long and slender and fuliginous in color. In the younger stages they are filled with small vacuoles. Later the vacuoles disappear and the spores become divided by from 10 to 12 septa. Fig. 11 shows 2 asci before maturity and 1 at maturity.

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* *Isaria-stage.*—The sporophores are simple, slender, terete or cylindrical, and white; they are borne in groups of from 2 to 10 on the dorsal surface of scale-insects belonging to the genus *Lecanium.* The sporophores are 1 to 2 mm. long, formed by the interlacing threads of mycelium and bearing sub-ovate conidia 2½ to 4 microns in size, on simple or once branched flask-shaped sterigmata, which are placed at right angles to the thread. The scale-insect on which these sporophores are borne is often surrounded by a simple fringe of mycelium (Fig. 98), which also bears conidia. The apices of these Isaria-sporophores become enlarged into the ascophores of the perfect stage.

On July 7 a dilution culture was made of the ascopores, using agar in which was a strong infusion of coccids. After two days, germination had commenced. The spores, usually remaining in the ascus, put out at various intervals slender, sinuous germ-tubes, containing fine granules. In some cases the tubes were closely packed coming from many of the segments of the spores (Fig. 13). After three days the threads become full of vacuoles, and constrictions appear between them. At this stage the plate became so badly contaminated with bacteria that it was impossible to further observe the development.

On potato the growth proceeds slowly, forming a dense dirty-white mat somewhat uneven in surface, and turning the adjacent potato a deep bluish black color.

The economic value of this fungus is probably small. The fungus abounds on scales which grow in damp and cool gorges, and refuses to flourish in dry situations. The cedar from which many of the specimens studied were obtained was situated on a dry hillside, and although the scales were very many of them full of hyphal bodies, no sporophores were afterward seen. It is possible that these hyphal bodies play an important part in the spread of the disease, and, being very inconspicuous, they may grow in this stage until conditions favorable to the production of the Isaria —or Cordyceps—stage are brought about. It would be very interesting to try experiments with scale-insects in a region having a moist climate or season suitable to the propagation of this disease.

CORDYCEPS MILITARIS (Linn.) Link.

On October 14, 1894, Miss Green, a student in the University, found a specimen of a *Cordyceps* partially buried in decaying leaves, in woodland, at Enfield gorge. Unfortunately no search was made for the insect, but the sporophores were simply pulled up and brought to the laboratory, Two sporophores were found about 3 cm. in length (Fig. 92). They were clavate in form and orange in color. The deep reddish perithecia are immersed in the light buff stroma. Near the base the perithecia are more prominent. The perithecia are conical, tipped with a pale yellow ostiolum, which is prominently pointed until the spores escape, when it collapses. The distal half of the sporophore is fertile. The spores are thrown out in a loose flocculent mass and remain clinging to the surface. They are about 1½ microns in diameter, and have segments 3 microns in length (Fig. 40). Eight spores are borne in a long tapering ascus (Fig. 39), the base of which is usually broken in preparing mounts, leaving the spores to protrude in a brush. The ascus is about 3½ or 4 microns in diameter.

This specimen was carefully compared with four specimens from Europe kindly loaned by Mr. J. B. Ellis. They differ slightly in having perithecia somewhat less deeply immersed, but the measurements are the same. The variety which is described on page 347 differs in having the perithecia not immersed, and in having the spores much larger. It also develops into the typical form of *Isaria farinosa* while the form under discussion produces a conidial stage quite different.

A dilution culture was made in the ordinary way using potato agar. Many segments of spores were sown. They were taken from the flocculent mass of spores protruding from the asci. No other spores were visible except the typical ascospores, but when germination took place, the growth appeared from rounded spores much larger than those sown. This was doubtfully explained by supposing that the large rounded spores were those of the corresponding Isaria-stage, which remained clinging to the sporophore after the manner of *Cordyceps clavulata.* It also brought up the case of the variety of *Cordyceps militaris* whose similar behavior had been partially explained in the same way. This explanation, however, did not make clear how the majority of the germinating spores were rounded, while those sown were, so far as seen, small and cylindrical.

Accordingly another dilution culture was started, and this time an examination was made soon after sowing. After one hour, numbers of the true Cordyceps-spores were visible but no rounded ones. After twenty hours there were visible many connected chains of rounded bodies, closely resembling the conidia of *Isaria farinosa.* In several cases large portions of the ascus were visible, with nearly all the segments of the spores swollen to the rounded form, and just enough of them retaining their original form to prove that they were really from the original ascus of the *Cordyceps*.

Germination from these swollen spore-segments takes place by the production of germ-tubes at one or two points. These soon become branched. The protoplasm is at first hyaline and homogeneous. After three days large vacuoles appear irregularly placed. The threads are strongly segmented and the branches are strongly constricted at the base. In some cases a healthy thread becomes suddenly constricted and produces an aborted apex of less than half the diameter of the ordinary thread (Fig. 45). The aborted portion is usually curled. In some cases the entire growth presents a much swollen appearance, being about twice the diameter of the ordinary threads. The segments of these swollen colonies always contain large vacuoles (Fig. 46). In about four days the growth appears above the surface of the agar. A strong, white cottony growth appears forming a colony circular in form. At the end of about six days the conidia appear. Short sterigmata are borne near the ends of the long, cottony threads. They are irregularly arranged either in an opposite or an alternate manner. They are flask-shaped and slender and sometimes forked. The conidia are nearly spherical and are borne in short chains of three or four at the ends of the sterigmata, or at the end of a long thread. The chains are seldom seen for they almost invariably collapse leaving the conidia in balls at the ends of the sterigmata. This is probably due to a thin film of moisture clinging to the surface.

The growth on potato becomes visible after about six days. The light yellow or white mycelium spreads loosely over the surface of the potato. After about a month the surface becomes densely felted, and in another month it becomes buff in color. The mycelium on the surface of the potato and the potato itself are colored pale orange or brilliant chrome yellow wherever they touch the glass. No Isaria-sporophores have been observed. A culture was made in a half-litre flask of potato, and quite a marked difference in the habit of growth was seen between this and the smaller tubes. The flask culture showed the beginning of a sporophore, deep reddish-orange in color, at the end of about three months. This is probably the beginning of an ascophore, since it appeared after the conidial growth had ceased, and at the same time that rudimentary perithecia were produced. The color also agrees with the color of the original specimen, which is in the perfect stage. At the end of two months, many small rounded bodies (Figs. 52 and 53), probably undeveloped perithecia, were developed in the potato just under the layer of mycelium. These bodies were usually spherical and measured from 100 to 240 microns. Sometimes two or three unite into a compound mass. No asci are visible on crushing them.

CORDYCEPS MILITARIS var.

The specimen from which this study was made was found by Professor Atkinson in the fall of 1893, on the lava of some unknown insect which was buried in rotten wood. The two slender orange colored sporophores protruded, bearing heads about 1½ mm. in diameter and 2 to 3 mm. in length. The entire sporophore is about 1 cm. in length. The heads of this form are apt to be more nearly globose than the typical form. The perithecia are crowded with their bases only, immersed. The form is conical, ending in a dark ostiolum. The asci are long, slender, tapering to a slender base. They are from 200 to 280 microns in length. The apex is slightly swollen and empty, giving the appearance of a hyaline cap. The long, slender spores are divided into segments about 3 microns in diameter, and 6 to 9 microns in length (Figs 21 and 22).

On May 31st, a dilution culture was made and from it a pure culture of a form apparently identical with *Isaria farinosa* was obtained. But as it was impossible to trace the germination from the cylindrical segments of the ascospores, a second dilution culture was made. The material was this time taken from an unripe portion of the head and no growth resulted. A third time the sowing was repeated in hopes of tracing the germination from the ascospores. At the end of two days, however, the spores from which the growth proceeded did not resemble ascospores but were oval and larger. The small number of ascospores was noticeable, for when sown, no spores except ascospores were visible, and after two days, fully three-fourths of the spores present were of the oval type. The cylindrical spores remaining refused to germinate. One more dilution culture was made with no better results, and the materials having been nearly exhausted, the attempt was abandoned. From a later study of *Cordyceps militaris*, I have come to believe that the largeroval type of spore is merely the inflated state of the true ascosphore. Although no oval spores were, in this case, seen to remain in chains, it would seem that the disappearance of the ascospores, and the simultaneous appearance of the oval type, which subsequently developed into the form apparently identical with *Isaria farinosa*, would prove the identity of the two. Potato cultures developedexactly as cultures obtained from the typical *Isaria farinosa*.

Tulasne was the first to remark the connection between *Isaria farinosa* and what he identified as *Cordyceps militaris*.* He says, the segments of the spores of *Cordyceps militaris* put out threads in germinating which branch after the manner of *Verticillium*, and bear coridia resembling those of *Isaria farinosa*. He also found what he took to be the conidia of *Isaria farinosa* among the "roots" of the ascosphores.

De Bary says: † "If the ascospores be sown in water or in nutrient solutions without a living host, they germinate and the germ-tubes develop hyphæ which branch with more or less copiousness according to the amount of nourishment supplied. In water only small plants are produced with few or no branches. Some of the branches spread in the nutrient solution, and have the power like the hyphæ on the inner surface of the caterpillar's skin, of adjoining cylindrical gonidia. It is true that this has not been observed in the species in question."

Since this form differs markedly from the typical *Cordyceps militaris* in the spore characters, it would be interesting to know if the specimens studied by De Bary and Tulasne, and thought by them to be connected with *Isaria farinosa*, possessed spore-characters identical with this form, or if the difference in the imperfect stages is due to variation. This question can only be settled by making cultures from the ascospores of various specimens.

Isaria farinosa (Dicks.) Fr.

The typical form.— The following study was made from material collected by Professor Atkinson in the fall of 1893, on an Arctiid cocoon buried in leaves in the woods. The cocoon was covered with sporophores about 3 or 4 cm. long. These sporophores are orange colored at the base, the apical two-thirds having a white farinaceous covering composed of colorless conidia, borne in a manner resembling that of *Penicillium* on loose threads which spring from the interwoven threads composing the sporophore. The conidia are borne in long chains on flask-shaped sterigmata which are grouped at the ends of short side branches.

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* Selecta Fungorum Carpologia.

† Comparative Morphology and Biology of Fungi, Mycetozoa and Bacteria.

A dilution culture was made from this. The growth in agar plates becomes apparent at the end of about twenty-four hours after the sowing of the conidia. They become swollen and put out one or two germ-tubes, usually at one or both ends of the slightly oval conidia. The protoplasm is homogeneous and hyaline. At the end of two days, the growth becomes apparent to the unaided eye. Branching occurs freely, the branches tapering and slightly constricted at the base. A few vacuoles appear and at the end of three days a few septa are to be seen, usually just beyond the point where a branch is attached. After about four days the threads are thrust up out of the agar, and in two more the colonies form beautiful, circular, cottony growths very finely radiated. The conidia now appear, borne on flask-shaped sterigmata which are placed either singly or in groups of from two to twelve on the main thread or on the end of a short side branch. The oval or nearly spherical conidia are borne in chains at the apices of the sterigmata.

A small depauperate form, probably of this species, was found feeding on a group of insect's eggs (Fig. 93). This specimen produced two sporophores, recumbent for a short distance, and then rising in a cylindrical mass of fibres for 6 or 7 mm. and bearing at the apex a spherical head about 1 mm. in diameter. One of the sporophores was forked just below the apex and bore two heads packed with loose chains of creamy white conidia. Plate-cultures from this specimen developed like those from the typical form, except that the threads became somewhat more swollen. A specimen found on decaying leaves showed a development coinciding exactly with the typical form.

On potato, the growth spreads rapidly over the entire surface, forming a dense, white covering of considerable thickness. This felt spreads evenly over the surface of the liquid and reaches to the glass walls of the tube. Isaria-sporophores are produced which grow directly away from the potato for a distance, when some of them reach the sides of the tube and grow directly upward for 2½ cm. or more, clinging to the glass, and flattening out considerably. Many short, round, rudimentary sporophores are produced all over the sides of the stick of potato. The bases of the sporophores are usually buff and the mycelium shows, where it touches the glass, a buff color at first which afterward becomes orange. In old cultures, long attenuated, the general color becomes buff or even pale orange.

A half-litre Ehrlmeyer-flask containing about 2 cm. in depth of potato on the bottom, was inoculated with conidia of *Isaria farinosa.* A very luxuriant, loose and white growth soon appeared, many sporophores being produced from 2½ to 4 cm. in length, covered with a farinaceous coat of conidia on the distal half. The flask, which had been previously kept in the dark, was placed in the light. In a short time a bright orange-color replaced the white to a great extent. On returning the flask to the dark, the growth became pale and a white, flocculent growth soon overspread the entire culture. On again bringing it to the light the orange-color reappeared.

EXPERIMENTS.

A number of white grubs, the larvæ of *Lachnosterna*, were dusted with conidia both from the original specimen and from potato culture, and after four months, no trace of the fungus was visible. Although most of the specimens died, they showed no trace of the fungus.

Fifteen specimens of *Pieris rapae* (larvæ) were dusted with conidia from a potato culture. After about twenty days the adult insects emerged.

Seven specimens of our common brown-and-black caterpillar, *Pyrrharctia isabella*, were infected with *Isaria farinosa* by sticking the conidia on the ventral and lateral surfaces with the white of an egg, by means of a brush. After twenty days, all but two showed that they were attacked by the fungus. Of the five attacked four were dead, curled up and covered more or less densely with a thick cottony mass of mycelium most prominent on the ventral side. One was yet alive although the ventral side bore patches of the mycelial growth. One of the dead larvæ was placed in a pot of sterilized sphagnum moss and placed in a moist chamber. After a little more than a month it had become completely covered with long Isaria-sporophores like those found on the original specimen. The remaining caterpillars and the two which subsequently contracted the disease, did not produce sporophores. They were left in the original cage which was constructed as follows: an ordinary flower-pot was placed inside of a large one and the space of about 2 cm. between them was packed with moss. The inner jar was closed by an inverted jar intermediate in size between the two. The moss packing was moistened daily, thus maintaining a humid atmosphere suitable for the best growth of the fungus, and approximating the conditions of the natural fall and spring home of the caterpillar.

ISARIA TENUIPES Peck.

The material from which the present study was made was obtained during the summer of 1894. Prof. Atkinson collected two specimens on the pupæ of unknown Arctiids, buried in leaves. From seven to ten slender, clavate sporophores arise from 1 to 1½ cm. above the pupæ. The distal half is flattened and densely covered with a farinaceous white powder composed of colorless conidia. The base is greenish-yellow and sterile. The conidia are oval to globose, hyaline, and measure from 2½ to 3½ microns in size.

On plate cultures germination becomes apparent in about twenty-four hours. The conida become swollen and put out from one to three slender germ-tubes which grow in a sinuous line from one or both ends of the conidium. A slight constriction and sometimes a septum separates the conidium from the base of the germ-tube. Often one or two vacuoles are present near the base of the largest germ-tube. The protoplasm is usually hyaline and homogeneous. After about forty-eight hours the threads appear above the agar in circular tufts. Many small and irregular vacuoles appear in the threads. Septa are sparingly and irregularly placed throughout the entire colony, and the branches are slightly constricted at the base. At the end of three days, the vacuoles become more thickly and regularly placed. The colonies by this time all appear above the surface of the agar, and some conidia are produced. The threads standing above the agar, bear short branches either in whorls, or placed in an opposite manner after the type of *Verticillium*. The conidia are borne either on the ends of these short branches or on short flask-shaped sterigmata grouped at the apex of a short branch. Those first produced cling to those next succeeding and so on until from two to eight conidia are collected forming a small spherical mass or sometimes an irregular chain. At the end of about four days, the threads usually spread over the surface of the plate in an even, flocculent layer, the colonies showing as points of denser growth. In case the conidia are thinly sown in making the dilution culture, the threads confine themselves to the colonies and do not spread.

On potato a dense white and cottony growth appears, and soon spreads over the surface. A yellowish buff tinge is noticeable very early. A bright greenish lemon-yellow is noticeable where the mycelium comes in contact with the glass. Sporophores soon appear rising from the sides and upper portions of the potato slab. In one case a sporophore 5 mm. in diameter grew from the side of the potato to a height of 4 cm. in a nearly vertical direction (Figs. 99 and 100). At this distance from the base, it divided into 15 smaller branches, some of them 2½ cm. in length and from 1½ to 2? mm. in diameter. All of these branches are covered with a dense, farinaceous yellowish-white coat composed of colorless conidia. Sometimes clavate branches are produced from 2 to 3½ mm. in diameter. Usually, however, the branches cling to the glass quite closely and are simple. A culture in an Ehrlmeyer-flask, having pieces of potato on the bottom to the depth of half an inch, grew much as in the case of a potato culture in a tube, except that the sporophores were in general larger and much more flattened and clavate, owing to the increased supply of food and air. Some of them were 2½ cm. long and over 1 cm. broad at the apex. They were about 4 mm. thick. The bases of the sporophores were tinged with lemon-yellow.

Several specimens of our common brown and black caterpillar, *Pyrrharctia isabella*, were dusted with conidia of this fungus and some of the caterpillars died. Two produced many yellowish sporophores from 2 to 3 mm. in length, in color closely resembling the original specimens. Unfortunately I have not been able to obtain a pure culture of any Isaria-like form from the specimens showing the sporophores. Specimens placed under like conditions, but not dusted, died, but did not show any signs of the fungus. The cause of the death of those exhibiting the fungus is, therefore uncertain.

CORDYCEPS MELOLONTHAE (?) (Tul.) Sacc.

Conidial stage (?).—On October 15, 1895, Mr. Pieters found a white grub, the larva of *Lachnosterna*, lying on the surface of the ground in one of the forcing-houses. It was covered with short, stout sporophores, both simple and branched, the one near the anus being fully 5 mm. long. A growth 6 mm. in length, bearing several short, spindle-shaped branches, issued from near the head. The grub was placed in damp sphagnum, to allow the development to proceed still further. After about two weeks the sporophores had attained a length of from 5 to 9 mm. and a diameter of 1 mm. sometimes expanded to 2 mm. On the sides of the sporophores are borne shining yellow disks, smooth and either plane or irregularly concave. These disks are composed of conidia held together by some viscid substance (Fig. 95). On removing the Isaria-sporophores, processes which are possibly the rudimentary stromata of *Cordyceps melolonthae* were seen. Several dilution cultures were made, using the ordinary agar, but the fungus refused to grow, further than to germinate. Potato agar was used, and the growth progressed slowly. After three days the conidia appeared swollen, and germination began by the production of one or two germ protubes. Vacuoles usually appear in the conidium and often at the base of the thread. In four days the threads grew to quite an extent, branching but little and showing no septa. The threads sometimes show swellings at their base. At the end of six days a few vacuoles and septa appeared. Many threads bear at their ends round or oval bodies (Figs. 58 and 60). The protoplasm in these is hyaline and homogeneous. Cylindrical conidia are borne in the agar after the manner of most of the Isarias studied. In order to get a pure culture on potato, a small piece of the agar containing growing mycelium was transferred to a slab of sterilized potato The growth on potato either spreads evenly over the surface or grows in raised patches. The mycelium is dirty yellow in color where it touches the glass of the tube. Conidia are borne in dense patches on the surface of the felt. The production of conidia does not always take place for this species in artificial cultures.

ISARIA ANISOPLIAE (Metch.) Var. AMERICANA. n. v.

During the fall of 1893 about 1300 wireworms were procured on which to experiment. They were chiefly larvæ of *Agriotes mancus.* At Christmas time a fungus was seen to be growing on them. It was provisionally identified as *Isaria anisopliae*, since the same fungus had previously been found by Mr. Slingerland in his experiments and sent to Dr. Thaxter, who identified it provisionally as *Metarrhizium anisopliae.** The genus *Metarrhizium* has since been included under *Isaria.* Thaxter† says *Entomophthora anisopliae* of Metchnikoff,‡ which attacks coleopterous larvæ, is perhaps an *Isaria*, the spores measuring 4.8 by 1.6 microns. It is placed by Sorokin as belonging to a genus of Basidiomcetes which he calls *Metarrhizium*."

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* Bull. No. 33 Cornell Exp. Station, p. 211.

† Mem. Bost. Soc. Nat. History, Vol. IV., No. 6, 1888.

‡ Zeitscher. d. K. Landwirth Gesell, of Neurussland, Odessa, 1879, pp. 21 to 50.

The larvæ first became rigid, and somewhat dull in color. Soon a white growth of mycelium appeared usually near the head or between the sclerites. These small patches spread in a folinaceous stroma, which is white and grows out into the surrounding soil for a distance of 3 mm. or more. Sometimes it spreads very thin and grows to a distance of 5 or 6 mm., clinging to the bits of vegetable matter in the soil. This white stroma at length becomes colored a dull sage green by the production of conidia. The conidia are from 5 to 7 microns in length and 3 microns in diameter. A dilution culture was made and germination became apparent in about twenty-four hours. The conidia become swollen, and the protoplasm becomes condensed at both ends of the oblong conidium. A slender germ tube is put out at one or both ends of the conidium. After one day more branching commences and by two days more, a few vacuoles appear. The branching growth increases steadily. In about six days the vacuoles become oval and regularly placed closed together throughout the entire length of the mycelium. The colonies assume an irregular stellate form. A pure white growth of branching threads appear above the surface and after about ten days from the sowing conidia appear, borne in chains on heads of a pexnicillate type (Figs. 73, 74, and 75). These heads are borne on short pedicels situated at short intervals on the main filaments. The production of conidia is accompanied by the appearance of a decided sage-green color.

On potato, the growth shows itself after about six days, in finely radiate colonies at the points of inoculation. A greenish center soon appears and the white growth quickly spreads over the entire surface of the potato forming a dense felt. This soon turns green by the production of conidia. After a time, the conidia become densely packed in a layer 1 mm. or more in thickness. The chains of conidia still preserve their connection, and a columnar structure is thus produced which extends through the layer perpendicular to the surface of the potato. When a piece of this crust is broken, the fracture follows the chains of conidia showing transverse striations. The mycelium is slightly yellow at first, but later it becomes tinged with green.

A number of specimens of *Agriotes mancus* were rolled in conidia of *Isaria anisopliæ* var. *americana* and placed in pots of earth in a box of moist moss; but the specimens in the check cages also died, both having been infected with the disease before they were taken from the storage pots. Those artificially infected died in greater numbers, but the appearance of the disease in the check cages makes it impossible to draw any positive conclusions. The wireworms contained in the storage cages all died before spring, and not a single click-beetle emerged. The spread of the disease was probably very much facilitated by searching for diseased specimens. In this way the soil, charged in places with conidia, became thoroughly mixed several times, thus carrying conidia to every part. The soil used was a sandy loam giving to packing hard. To prevent this, a small amount of finely broken *Sphagnum* was mixed with it. Wherever this *Sphagnum* had not been thoroughly mixed, and remained in small masses, the disease was most prevalent. Larvæ lying in or near such masses were almost sure to be attacked, the foliaceous stroma spread over the surface apparently deriving some nourishment therefrom. This suggests that possibly a loosening of the soil may be of some advantage where wireworms are abundant, especially if the disease be present. The cages in which they were confined were prepared as follows: About three hundred larvæ were placed in an ordinary plant jar filled with soil prepared as described. Wheat and clover were sown on the surface and a large glass cylinder, such as is used for breeding insects, was placed over the jar, and its upper end closed with muslin. This jar was then placed in a second jar and the space of about an inch between was packed with moss, which was daily moistened. Enough moisture passed through the inner porous jar to supply the needs of the enclosed larvæ.

ISARIA ANISOPLIAE (Metch.).*

A pure culture of a fungus working on wireworms, *Anisoplia*, was received, labeled *Isaria destructor* (Metch.), from France communicated by Professor Alfred Giard. A dilution culture was made, and germination commenced before the end of one day. The conidia became swollen and from one to three germ-tubes were put out. During the succeeding growth, branching occurs freely. The diameter of the threads varies considerably, some being swollen and tapering (Figs. 63 and 64). They contain many vacuoles and granules. At the end of a week, some of the threads become inflated as shown in Figs. 65 and 66. The growth by this time appears above the agar. The growth is very much branched and closely packed, producing a very dense stellate or coarsely radiate growth. In two days more the colonies become tinged with green, by the production of conidia. The growth is so dense that it has been impossible to observe the conidia remaining attached to their sterigmata. Small pieces of the agar covered with conidia bearing mycelium, when placed in water under the microscope, show a fructification closely resembling that of *Penicillium*. The branched mycelium bears heads which are branched like *Penicillium* and which bear long chains of conidia, cylindrical in form and rounded at the ends. A refringent body is usually seen near each end. They measure about 3 microns in diameter, and from 6 to 7 microns in length. This mass of conidia forms a dense and compact covering for the mycelium.

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* Krassilschik says (Bull. Sci. de Fr. et de la Bel. Jan.—Avr. 1893—translation in French) and (Jour. Mycol, Vol. V. 1889, translation in English): That the genus *Metarrhizium* was established by Professor Sorokin for the Green Muscardine discovered by Metchnikoff upon the larvæ of *Anisoplia austriaca* and first named by him *Entomophthora anisopliæ.* But Metchnikoff since gave it the name of *Isaria destructor*. The name *Metarrhizium* was thus dropped, as the other members of the genus were imperfectly established. So if the first specific name is retained it would be *Isaria anisopliæ* (Metch.)

On potato, the growth spreads over the surface of the potato from the points of inoculation, showing at the end of six days many elevated white points. A marked green color is visible in many places where the mycelium touches the glass; and where a felt is spread over the surface of the liquid, the entire growth becomes gradually colored a deep bottle-green by the production ot conidia. Sometimes a narrow white border is left uncolored.

The growth is more compact and the color is darker than in the case of variety *americana*. The potato and liquid are tinged with green as well as the mycelium where it reaches the walls of the tube. The same columnar structure is seen in the crust of conidia as in the case of the var. *americana*.

Two cultures were started on the same day in Ehrlmeyer-flasks, filled with sterilized potato to the depth of three-fourths of an inch. One flask was inoculated with conidia of *Isaria anisopliæ* and the other with the variety *americana*. The variety *americana* grew in a white, elevated, comparatively loose felt all over the surface of the potato. *Isaria anisopliæ* spread comparatively little, growing less vigorously, and in patches not covering more than one-fourth of the surface. The felt produced is much less elevated. After about two weeks the dull sage-green color appeared quite perceptibly in the variety *americana*. In *Isaria anisopliæ* the dark bottle-green color appears somewhat earlier. The growth of *Isaria anisopliæ* subsequently spreads over the entire surface of the potato. *Isaria anisopliæ* has a very dense, farinaceous appearance, while the variety has a looser cottony one. The color of *Isaria anisopliæ* is a deep brownish bottle-green, with the color of the mycelium distinctly green where it touches the glass. The color of the variety *americana* on the other hand is dull sage-green, with the mycelium buff yellow. These characters have been constant during a long series of cultures.

Krassilschik speaks of the coremium-form which sometimes appears on potato cultures. This is produced as follows: the branches of the mycelium bear in old cultures a dense crust of conidia having a columnar structure. Now small isolated patches of conidia-bearing mycelium often produce a small mass of conidia which cling together, producing small pieces of crust having this columnar structure, and sometimes showing the white mycelium beneath. This method of growth resembles *Coremium* quite closely but differs from the typical coremium method of growth. Professor Metchnikoff gives a short abstract* of his investigations on the fungus diseases of insects, during the year 1878, together with some more recent observations on the practical application of parasitic fungi for the destruction of injurious species. The original contribution is in the Russian language, "On the Diseases of the Larvæ of the Grain-beetle" (Odessa, 1878). Professor Metchnikoff found that the *Anisoplia austriaca* larva, which lives in the ground, is subject to several diseases, one of which he calls the "Green Muscardine," being produced by a parasitic fungus *Isaria destructor* (*anisopliæ*). The same fungus was also found to infest another beetle, *Cleonis punctiventris*, which is very injurious to beets. In the month of August, when the disease had not yet disappeared, about forty-five per cent. of the progeny of these latter beetles was destroyed. Of the experiments made to infest the *Anisoplia* larvæ with the spores of *Isaria*, several were successful, but in some cases the larvæ remained healthy for a long time. The same experiments made to infest the *Cleonus* larvæ were eminently successful. Of ninety larvæ, which for a short time were brought in contact with the spores, sixty-two died from Muscardine within twelve days. On the imago of the *Cleonus*, the Muscardine acts somewhat more slowly, but just as surely. Of fifty-eight beetles which he infected when fresh from the pupa, fifty-two died from Muscardine within fifteen days. From these and other experiments, Professor Metchnikoff concludes that *Isaria destructor* produces an epizootic disease of the insects mentioned, and believes it possible to produce the disease by sowing the spores.

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* Zoologisher Anzeiger No. 47, pp. 44–47. (Riley, Am. Ent. Vol. III, p. 103, 1880).

ISARIA DENSA (Link.) Fries.

A pure culture of this fungus was obtained from Fribourg and Hesse, Paris. In describing the appearance of insects killed by the fungus, Giard says that the fungus appears in nature under very characteristic forms. In dry places the bodies of white grubs are hard and covered with a sparse white down which becomes pulverulent as the age becomes greater. In moist and clay soil the fungus sends out irregular prolongations from 5 to 6 cm. or even more in length. These prolongations cement the particles of earth and roots of vegetation. They often stretch from one mummy to another. He speaks of these prolongations as sporophores, comparing them to the aerial sporophores of the other Isarias. Both are sometimes sterile and sometimes fertile, and both are usually preceded by an enveloping stage. He ends by saying that the difference between the *Isaria* of the June bug, and the other Isarias is of the same nature as the difference between an aerial stem and a rhizome in the Phanerogamia.

A dilution culture was made from the pure culture obtained from Paris, and the following characteristics of growth noted. Germination begins after about two days. The conidia become swollen and put out two or three germ-tubes (Fig. 23.) Soon the oval vacuoles become abundant and a few septa appear. After about four days the threads become full of large vacuoles (Fig. 25). The threads now become irregular in size. Some are large and inflated, the small ones are usually tapering and constricted at the base (Fig. 29). Elongate spores are thrown off in the agar, from the ends of short branches. The colonies are at this time finely radiated, and about 3 mm. in size. In a week's time many strands are to be seen, formed by several threads growing together for some distance. The growth appears above the agar in about ten days. The colonies continue to grow and branch until, at the end of about two weeks, they form even, fluffy, and strongly raised colonies. Soon after this, conidia are produced on flasked-shaped sterigmata, which are either sessile or borne on short side branches. These sterigmata and the chains of conidia become crowded so as to form heads of some size like those of *Sporortrichum* (Figs. 26, 27, 28, and 30).

On potato the growth starts from the points of inoculation and grows until, at the end of about a week, it appears as a lobulated white mass, strongly raised from the surface of the potato. The pure white mycelium contrasts strongly with the potato which is colored a deep purple by the fungus. After about two weeks the conidia give the growth a creamy, farinaceous appearance. Wherever the felty membrane resting on the surface of the liquid comes in contact with the glass tube, a delicate fringe of very fine white threads runs up which cling to the glass and preserve perfectly parallel courses. Culture in half-litre Ehrlmeyer flasks showed exactly the same method of growth. Gelatine is colored a deep vinaceous purple when the fungus is grown in it.

On October 31, 1893, twenty larvæ of *Lachnosterna* were infected with *Isaria densa* in the following manner: Twenty grubs were placed in an earthen dish containing soil to the depth of about 1 cm. Half the contents of the tube just received from Fribourg and Hesse was mixed with half the white of an egg, and 15 cc. of water added. This was beaten and each grub carefully touched behind the head and along the sides with the liquid. The remainder of the liquid was poured over them and the dish and grubs covered with moist moss, and placed in a room of ordinary temperture. On November 1st, the grubs were placed in two pots, ten in each, and covered with earth and moss full of conidia. Wheat was sown over the surface of the soil. On November 14th, five were dead; two had just died and were very much swollen. On November 20th, the swollen ones were pink. One of them was firm and apparently full of mycelium; the other was attacked by bacteria and became a putrid mass. Several of the grubs were the centers of nodules of vegetable matter and soil, but the fungus binding them together proved to be a harmless *Mucor*. One grub was seen on November 29th, which bore a white fungus on the surface. It was, together with the swollen one mentioned, rubbed on nine healthy grubs and placed with them in a new pot.

On February 26th, however, no effect was seen and the experiment was discontinued. The specimens in the check-cages, died at about the same rate, but none of them became swollen or pink in color. It is possible that the two grubs were attacked and killed by *Isaria* but it does not seem to act with the same virulence that is reported from Europe, possibly because of different climatic conditions and possibly also because of the difference in the host.

Perraud records experiments with *Botrytis tenella* (*Isaria densa*) in closed chambers. They were successful when small chambers were used, but when larger chambers were used, the experiments were less successful. He does not speak of its economic use.

Paul Sorauer* says that the results of his experiments show that the insects are rendered susceptible by being placed under unfavorable conditions, such as being provided with poor or insufficient food, or placed in a soil which is too moist. The latter is also favorable to the development of the fungus.

Dr. Jean Dufour in Lusanne † finds it very easy to produce the disease in specimens infected with the conidia, but finds it very difficult to spread the disease. He thinks that it is impossible for the grubs to spread it themselves to any useful degree. His experience is corroborated by Frank ‡ who says, that the question is more difficult than it would appear. The difficulty does not consist in finding a parasite on the grub, but in spreading it.

M. E. Le Coeur ‖ infected also *Anthonomus pomorum* and *Cheimatobia brumata* with *Botrytis tenella*. Most of the pupæ remained dead in the ground.

My experiments were rendered very unsatisfactory because of what was apparently a bacterial disease, which broke out in the storage cages, as well as out of doors in places where grubs were abundant. The grubs showed small well-defined, irregularly-shaped patches of black, shiny skin, usually on the thorax at the bases of the legs, and often on the legs themselves. In such cases the legs dropped off as the disease advanced. Often the black patches appeared on the dorsal-surface, just behind the head, and occasionally on any part of the body. These patches of blackened skin grew in size until sometimes the greater part of the insect was covered ; but usually the grub died before the patches covered more than a small portion and subsequently it became a loose skin filled with a putrid mass. The grub became usually inactive soon after the first appearance of the patches. This disease apparently killed off the grubs under observation and became a general nuisance. A dilution, culture from the diseased grubs was made and several species of bacteria obtained, but none in sufficient quantity to point to it as the cause of the disease. The fact that the grubs, placed as checks to the other experiments, were constantly dying rendered it impossible to determine by infection experiments, which was the pathogenic species. It is remarkable that the next season, that of 1894, was noticeable for the absence of June-bugs. Very few were seen at Ithaca. It is to be hoped that larvæ showing the appearance of a disease such as described, may be found at some future time and the matter further investigated.

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* Zeit. für Pflanzenkrankheiten, Vol. IV, p. 267.

† Zeit. für Pflanzenkrankheiten, Vol. III, p. 143, 1893.

‡ Deutsche Landwirtschaftliche Presse, vom 19, Nov., 1892, p. 961.

‖ Bull. de la Soc. Mycol. de la Fr., Vol. VIII, p. 20, 1892.

SPOROTRICHUM GLOBULIFERUM Speg.

This species usually appears in nature as a loose, white, cottony growth enveloping its insect host in fine filaments which bear at irregular but short intervals minute heads composed of conidia closely packed into a nearly spherical form. These heads are sessile and creamy white in color.

This should probably be regarded as a form species, the real species being in this stage, indistinguishable. In artifical cultures from the *Sporotrichum globuliferum* taken from nature, some of the forms progress to higher stages of development representing widely different species. These forms may some of them grow differently in nature. Professor Forbes* describes and figures several insects on which true Isaria-sporophores were produced by infecting with a form found on a dead insect larva.

In this sense the form species *Sporotrichum globuliferum* is analagous to the old *Oidium erysiphoides*, a form species representing the conidial stage of various genera of the *Erysipheae*.

The typical form originally described as *Sporotrichum globuliferum* was probably identical with the following which was found on a carabid beetle in October, 1894, by Mr. Pieters. The growth occurred in patches of conidia-covered mycelium from 1 to 1½ mm.

in size. These patches are distributed irregularly over the head and ventral side of the body. The spherical conidia are borne in spherical heads on the sides of the long slender mycelial threads. This species seems to be the original *Sporotrichum globuliferum* † which was first found on Carabidae, and which appeared as in this case in patches on the surface and not in a dense felt as in the case of several other Sporotrichums hitherto identified as *globuliferum.*

A dilution culture was made in the usual way, and the following habit of growth observed: after one day the conidia become swollen and one or more germ-tubes are developed. These germ-tubes are strongly constricted at the base. The protoplasm is hyaline. In two days the threads become somewhat branched, with the branches also constricted at the base. Some vacuoles appear about this time. In three days cylindrical conidia are thrown off in the agar from the terminations of slender threads (Fig. 82). In about four days after sowing, the threads appear above the agar, forming radiate colonies which continue to enlarge until, at the end of a week, the colonies are 2 mm. in diameter, and strongly elevated, some being almost hemispherical. After this an even, loose growth usually spreads over the entire surface, connecting the colonies. On about the eighth day the threads become swollen and in many cases the protoplasm becomes concentrated in certain parts, leaving the other parts empty (Fig. 87 and 88). On about the thirteenth day the parts containing protoplasm germinate. They put out long slender tubes which grow as ordinary germ-tubes and produce cylindrical spores in the agar, as in the case of ordinary threads from aerial conidia. Sometimes a pair of spores will be produced and the parent thread will lengthen and leave these behind, producing another pair beyond. The protoplasm in these segments is nearly homogeneous, the walls being somewhat thickened. This shows how segments of mycelium may function as conidia, and suggests how the hyphal bodies of *Cordyceps clavulata* may be produced. After about four days from the sowing, conidia are borne outside of the agar. The sterigmata are terminal or sessile on the ends of short branches. The sterigmata are tipped with small spherical conidia (Figs. 84, 85, 86 and 90). The multiplication of these sterigmata and conidia results in a more or less compact head, spherical in form (Fig. 83).

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[*] Bull. No. 38. Ag. Exp. Sta. Univ. of Ill., p. 33. Mar. 1895.

[†] Speg. Fungi. Argent. Pug., II. p. 42.

A culture was made in an Ehrlmeyer-flask partially filled with pieces of sterilized potato. The growth quickly spreads over the entire surface. At the end of about four days, the potato was tinged purple in the near vicinity of the colonies. This color is soon obscured by the dense felt of mycelium which covers the surface, and which becomes strongly wrinkled as growth advances. No sporophores are produced but the surface is covered by a thick coating of creamy white conidia.

SPOROTRICHUM GLOBULIFERUM ON THE CHINCH-BUG.

In the fall of 1893, Chancellor Snow, of Kansas, kindly sent me a box of chinch-bugs covered with a growth of the so-called *Sporotrichum globuliferum* which has been used to such an extent against the ravages of these insects. A pure culture was obtained, but unfortunately the cultures were neglected and died before a careful study of its growth on potato and other media could be made The growth on the bug is in the form of a dense felt, not exactly such as occurs in the typical form on the carabid beetle, but indistinguishable from it as far as microscopic appearance goes. Cultures in large flasks may prove it to be the same. A number of experiments were made attempting to produce the disease artificially on various insects. About one hundred live aphids, *Aphis brassicae*, were placed in a cage on a kohlrabbi, and thoroughly dusted with conidia. After about a month had passed, no effects were noticeable and the experiment was discontinued. Many specimens of wireworm, *Agriotes mancus*, were rolled in a Petrie-dish full of conidia and were then placed in moist soil None of them developed the fungus. Out of four carefully conducted experiments with white grubs, larvæ of *Lachnosterna*, only one succeeded. Many grubs were dusted with conidia from potato cultures, or rolled in Petrie-dishes containing fruiting threads. Some were even touched with the infected bugs themselves. All of the grubs lived and showed no signs of the fungus. One, however, of five grubs dusted with conidia obtained from a sterilized grub, on which the fungus had been grown, succumbed, and showed the disease in its characteristic form. From this a pure culture was obtained by means of a dilution culture. The experiments were on the whole unsuccessful, but as they were carried on with insects not the natural host of the fungus, they prove nothing as to its efficacy against the chinch-bug.

ISARIA VEXANS N. SP.

A larva of *Lachnosterna* found April 7, 1894, by Mr. M. V. Slingerland in a breeding-cage at the insectary, was completely covered with a felted white coat of *Sporotrichum globuliferum*, bearing patches of creamy-white conidia. A microscopic examination showed the fructification to be exactly as in the case of the typical *Sporotrichum globuliferum*. A dilution culture was made, and germination became apparent at the end of one day. The development is as follows: The nearly spherical conidia become swollen and produce a germ-tube which grows in a sinuous line, branching occasionally and producing many long, cylindrical conidia in the agar. These are borne at the end of a filament, and each spore is successively pushed aside by the one next produced, resulting usually in a cluster of spores placed side by side (Fig. 18). Branching soon commences and septa are often present just beyond the base of the branches. Small vacuoles appear, usually irregularly placed. At the end of about three days the growth appears above the agar in loose, cottony filaments, each colony becoming circular in form and finely radiated. After one more day the conidia appear (Fig. 16). Short sterigmata bear one or two conidia on short pedicels. These conidia increase in number and the sterigmata lengthen and multiply until at the end of a week large heads are formed (Fig. 20). The threads anastomose freely (Fig. 15). In places where the colonies have been crowded they assume a smaller stellate form instead of the ordinary circular form.

On potato the growth spreads over the entire surface in a felted layer, afterwards becoming densely covered with a farinaceous, creamy-white layer composed of colorless conidia. Isaria-sporophores are often produced. In 1 tube are 10, ranging from 2 to 4 mm. in height. They are usually clavate in form, being sometimes 3 mm. in diameter at the apex, tapering to 1 mm. at the base. On one side a long, pointed sporophore springs from a point near the glass, but free from it. It is slender and measures 8 mm. in length by about 1½ mm. in diameter at the base. At another point 2 about 1 mm. broad spring from the same base, where the potato touches the glass, and grow to a length of 1 cm. They are flattened and cling to the glass of the tube for their entire length. Wherever the mycelium touches the glass it is seen to have a bright buff color.

A culture was started in a half-liter Ehrlmeyer flask, having about 4 cm. in depth of potato in small pieces at the bottom. In about two weeks a growth spread over the entire surface. The potato was colored a distinct purple, considerably less intense than in the case of *Isaria densa*. After about 20 days the entire surface became marked with a creamy-white covering composed of conidia. In many places there appeared crowded radiating growths of threads, spherical in form, having a creamy-white color and a velvety appearance. The buff color is usually more pronounced at the base and center of such spherical growths; the growth is also more dense at these places. In five or six days more the velvety pile collapses gradually, and from 3 to 15 cylindrical processes are produced in its place. These present a color more intensely creamy than the velvet balls from which they spring. The cylindrical sporophores seem to protrude through the sphere at the same time that the pile collapses. They develop into long, slender, erect and usually clavate sporophores, generally simple though sometimes branched. They occasionally reach the length of 2½ cm. The color of the mycelium, where it touches the glass, is orange. These characters show this form to be an *Isaria*, and the name *Isaria vexans* is here proposed for it.

This method of growing fungi in flasks, allows the fungus to reach a maturity that is impossible in the smaller tubes, because of the insufficient supply of moisture and nutriment.

Infection experiments were made with four species of insects. Twenty-four larvæ of our common cabbage-butterfly, *Pieris rapæ*, were dusted with conidia obtained from a potato culture. After five days, four of the larvæ were dead, and colored a deep vinaceous purple. In places were patches of a white felty growth of the mycelium. After five days more, the remainder of the larvæ had pupated, excepting one which soon died. After seven days more, three out of the original twenty-four emerged, all the rest having succumbed. In the case of pupæ, the disease invariably starts from the wing-pads. Its presence is indicated by a deep purple color which spreads from the wing-pads over the entire body. This purple color is also noted by Professor Forbes* who finds cabbage-worms are turned purple when attacked by the fungus used against the chinch-bug. The death of the insect may not occur until the disease has become well advanced. The pupæ sometimes move spasmodically when irritated, even after the color has spread all over the pads and to some adjacent parts of the thorax. After the death of the insect, the mycelium appears as a close felt spreading over the entire surface of the body. All the specimens in the check cages remained unaffected and well throughout, all of them emerging as adults. A dilution culture proved the fungus to be the same as that originally used for infection.

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* Bull. No. 38, Ag. Exp. Sta. of the Univ. of Ill., 1895, p. 33 and 43–44.

On August 18, 1894, about forty Harlequin Milkweed caterpillars, *Cycnia egle*, were dusted with conidia of the fungus. After five weeks no effects were visible. The caterpillars grew and eventually pupated. The pupæ did not exhibit any traces of the fungus.

Two large cages of our common Fall Webb-worm *Hyphantria cunea*, were dusted with conidia obtained from a potato culture. After five weeks no results were visible. Eventually they nearly all pupated, presenting no traces of the fungus.

On August 22, 1894, thirty caterpillars of the Red-humped Apple-worm, *Oedemasia concinna*, were dusted with conidia obtained from a potato culture. After about a month, eight caterpillars and two pupæ were found to be dead and completely covered with a characteristic felt which exhibited the ordinary mode of growth and fruiting.

A cage containing caterpillars of *Melitea phaeton* stood near the cage of infected cabbage-worms, and three of these became accidentally infested and died, producing the characteristic growth.

The cages used in the experiments described, were ordinary glass cylinders closed at the upper end with muslin. The air in them was slightly, if at all, more humid than that outside.

A culture tube, in which Mr. Pieters was growing a pyrenomycetous fungus, was left open for a short time and a number of our small red ants, troublesome in the laboratory, entered, probably bringing the conidia of this fungus with them on their bodies. The cotton plug of the culture-tube was reinserted and the ants left to their fate. They died in about a week and in due time, became covered with a white growth of the fungus, the conditions being favorable to its development. The growth was in this case loose and fluffy. A dilution culture and pure cultures, in flasks of potato, proved it to be the species in question.

SPOROTRICHUM GLOBULIFERUM ON *Vespa* sp. (Probably *Isaria* sp.)

On October 29, 1894, Mr. Pieters found a specimen of *Vespa* sp. almost covered with a thick felted growth of a white fungus. A microscopic examination failed to reveal any characters which would differentiate it from *Sporotrichum globuliferum*. The heads of small spherical conidia were borne on threads exactly as in the case of the typical specimens. A dilution culture was made and the following habit of growth noted: germination becomes apparent after about twenty four hours. One or two germ-tubes are put forth which grow in a sinuous line and soon begin to branch, throwing off a great number of cylindrical spores in the agar. The protoplasm is hyaline. There are very few vacuoles at first, but they soon appear, becoming plentiful at the end of three days. In four days many of the cylindrical spores germinate, putting out slender tubes and growing as in the case of ordinary conidia. These cylindrical spores may be broadly oval or long and slender. They are present in greatest numbers in the places of crowded growth. The threads emerge from the agar on about the fifth day. A loose, puffy, strongly elevated growth appears, which soon becomes crowded with conidia. The threads bear many short sterigmata at irregular intervals and irregularly placed, often whorled. These sterigmata bear from one to six oval, nearly spherical conidia about $1\frac{3}{4}$ to $2\frac{1}{2}$ microns in size. The multiplication of these sterigmata and conidia soon forms an irregular or spherical head. The threads anastomose freely. After ten days the colonies attain the size of 2 cm. in diameter, where they are not crowded, the central two-thirds being colored white by conidia, the outer margin being finely radiate in the agar.

On potato, the growth spreads evenly and loosely over the surface. A dense, firm weft is formed over the surface of the liquid. At the end of six days the mycelium is creamy yellow where it touches the glass. Later it turns buffs and sometimes almost red, at the surface of the liquid. The white aerial mycelium sometimes bears Isaria-sporophores, formed by the interlacing of threads, 2 cm. or more in length. Cultures in Ehrlmeyer-flasks grow the same as in tubes, except that the potato is colored slightly purple in the near vicinity of the colonies, after about the seventh day. This color usually fades out soon. Many strong sporophores are produced all over the surface of the potato, some of them measuring 2 to 3 cm. in length and 1 cm. in breadth. They are usually flattened.

SPOROTRICHUM MINIMUM Speg.

On December 18, 1894, Mr. Martin, a student in the University, found a large black ant, *Camponotus*, under the bark of a decaying log. The insect was covered with a growth of white mycelium, but no conidia were visible. It was placed in a moist-chamber for a few days, when great numbers of small spherical conidia made their appearance, borne in loose branching heads identical with those produced in artificial cultures. Nearly the entire insect was covered with a dense, white, felted growth of mycelium.

On December 26th, a dilution culture was made. After two days, the conidia become swollen and one or two germ-tubes are put out which branch freely (Fig. 34). The threads are continuous and the protoplasm is hyaline. Cylindrical spores, either short and broad, or elongated, are thrown off in the agar (Figs. 35 and 36). By the end of three days, the threads begin to emerge from the surface of the agar. Many septa appear now irregularly placed. The conidia appear on about the eighth day. The threads spread loosely over the surface of the agar, and the short, lateral or terminal branches bear flask-shaped sterigmata, either singly or in groups. The microscopic growth on the plate is at first coarsely stellate, afterward becoming finely radiate and more dense. A small, dense, conidia-bearing mass of mycelium is usually formed at the center of the colony, and a looser tangle of threads bearing conidia usually covers the colony, sometimes spreading over the entire plate. A good deal of variation is noticeable. The periphery of the colony is usually fringed with a fine feathery growth in the agar composed of either curved or straight strands, made up of several filaments. The sterigmata are flask-shaped and bear at the apex a single conidium or more often three to six conidia collected into a compact ball, probably held together by some viscid substance which prevents their forming chains and draws back the ones first produced causing them to adhere at the sides of the later conidia.

On potato the growth spreads very slowly over the surface forming a close felt, white, and not strongly raised from the surface of the potato. The mycelium is yellow where it touches the glass. No Isaria-sporophores are produced.

Mr. Walsh* early suggested the use of entomogenous fungi as insectides. Since that time there have been many experiments, some of which seem to show the subject to be of considerable economic importance. Among those who have done the most toward testing the value of fungi as insectides, are Professor Giard, in France, who has carried on many experiments with *Isaria densa*, and several other species. From the reports of Chancellor Snow, it would seem that *Sporotrichum globuliferum* might be used effectively against the chinch-bug. Professor S. A. Forbes has worked on many forms in Illinois, but has paid especial attention to *Sporotrichum globuliferum* and the chinch bug. Professor Roland Thaxter has carried on careful experiments with the Entomophthoreae although usually obtaining negative results. M. J. Perraud and M. Paul Soraur as well as Dr. Dufour and M. Le Coeur have experimented with *Isaria densa* but they have usually obtained negative results.

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EXPLANATION OF PLATES.

Cordyceps clavulata. Plates I and II.

1. Hyphal bodies from *Lecanium* on Maple.
2. Hyphal bodies in agar after three days.
3. Hyphal bodies germinating in the body of a coccid.
4. Hyphal bodies from *Lecanium fletcheri.*
5. Hyphal bodies from *L. fletcheri* in agar after one day.
6. Mycelium from Fig. 5, after five days.
7. Mycelium from Fig. 5, after two days.
8. Hyphal bodies from *Lecanium* on Maple after two days.
9. Threads and sterigmata bearing conidia from cultures.
10. Threads and sterigmata bearing conidia from coccid.
11. Asci of perfect form.
12. Spores of perfect form.
13. Germination of ascospores in agar after two days.
14. Longisection of head of perfect stage.

Isaria vexans n. sp. Plate III.

15. Threads anastomosing after one week.
16. The first conidia, four days.
17. Germination of conidia in agar, one day.
18. Cylindrical spores in the agar, two days.
19. The same as Fig. 16.
20. Heads of conidia after one week.

Cordyceps militaris var. Plate III.

21. Ascus.
22. Single spore and segiments. Plate III.

Isaria densa.

23. Germination of conidia in agar, two days.
24. Germination of conidia in agar, three days.
25. Threads after four days.

26, 27 and 28. Sterigmata and conidia after two weeks.

29. Swollen threads after six days.
30. The same as Fig. 27.

Isaria farinosa. Plate IV.

31. Germination of conidia after one day.
32. Colony after two days.
33. Threads bearing conidia, after six days.

Sporotrichum minimum. Plate IV.

34. Germination of conidia, after two days.
35. Cylindrical spores borne in the agar, after two days.
36. The some after three days.
37 and 38. Threads bearing conidia after eight days.

Cordyceps militaris. Plate V.

39. Asci.
40. Segment of spore.
41. Connected segments of spores in agar, twenty hours.
42, 43, and 44. Spore-segments germinating after forty hours.
45 and 46. Colonies after three days.
47–51. Threads bearing conidia, six days after sowing.
52 and 53. Immature perithecia in potato cultures.

Cordyceps melolonthæ (?) Plate VI.

54. Conidia.
55. Conidia, germinating after three days.
56, 57, 58, 59. Portions of colonies showing oval bodies in the agar.
60. Oval body detached,
61. Colony after four days.

Isarias anisopliæ. Plate VI.

62. Conidia, germanating in agar after one day.
63. Conidia germinating in agar, after two days.
64. Colonies after three days.
65 and 66. Threads after six days.
67 and 68. Conidia-bearing heads and conidia.

Isaria anisopliæ americana. Plate VII.

69. Conidia in agar.
70. Conidia germinating in agar, after forty-eight hours.
71. Colony after three days.
72. Colony after seven days.
73, 74, and 75. Heads bearing conidia.

Isaria tenuipes. Plate VII.

76. Conidia germinating after twenty-four hours.
77. Colony after two days.
78. and 79. Threads bearing conidia after four days.

Sporotrichum globuliferum, from Carabid beetle. Plate VIII.

80. Conidia germinating after one day.
81. Colony after two days.
82. Cylindrical spores in the agar, three days.
83, 84, 85, and 86. Threads bearing conidia.
87, 88, and 89. Segments of threads in agar germinating after thirteen days.
90. The same as Fig. 84.

Isaria farinosa. Plate IX.

91. On Arctiid larva. x 2.

Cordyceps militaris. Plate IX.

92. On unknown insect. x 1½.

Isaria farinosa. Plate IX.

93. Depauperate form on insect eggs.

Sporotrichum globuliferum (*Isaria* sp. ?) Plate IX.

94. On *Vespa.* x 2.

Cordyceps melononthæ, conidial stage. Plate X.

95. On White grub.

Isaria archnophila. Plate X.

96. On unknown spider.

Cordyceps clavulata. Plate X.

97. Perfect stage. x 2.
98. Isaria stage. x 2.

Isaria tenuipes. Plate XI.

99 and 100. Two views of the same culture on potatoes.

Isaria vexans. Plate XI.

101. Culture in flask on potato.

The drawings of the development of the forms figured were made with a camera-lucida and are, with the exception of Figs. 14, 52, and 53, magnified thirty-three times more than the scale which is ruled to one-tenth of a millimeter. Figs. 52 and 53 are magnified five times more than the scale.

RUFUS HIRAM HATCH.

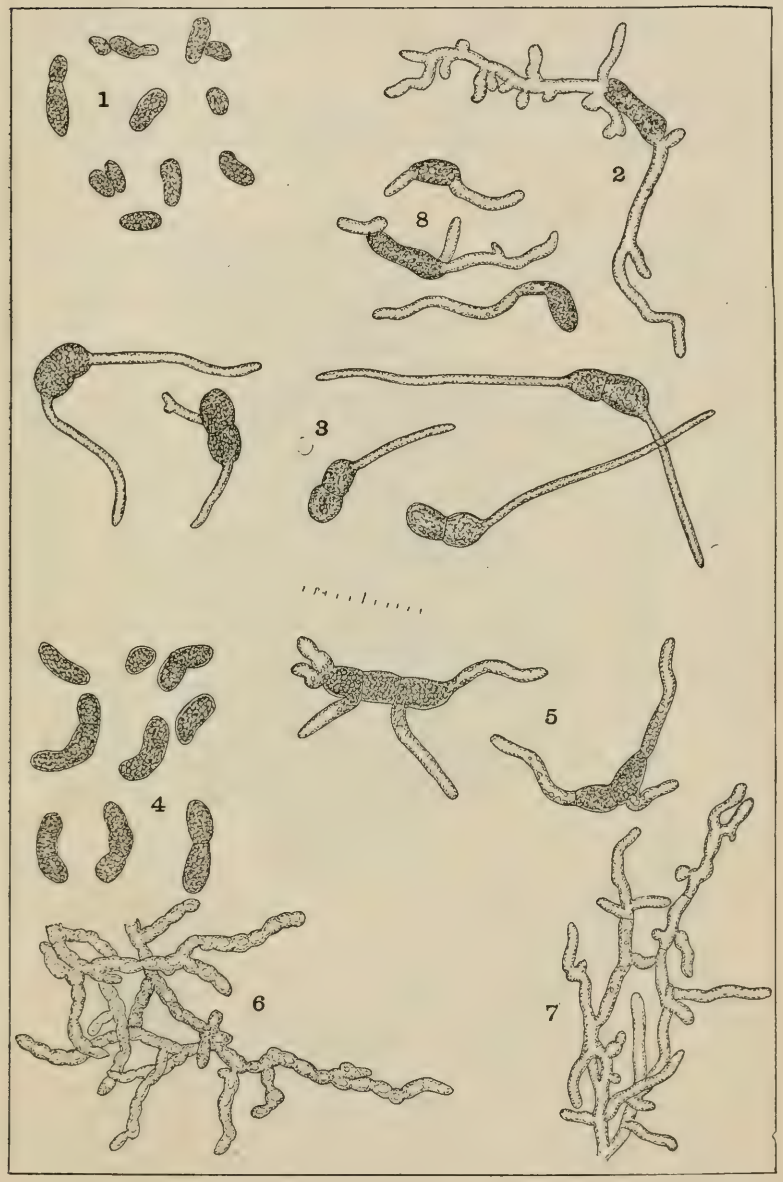

PLATE I.—Cordyceps clavulata.

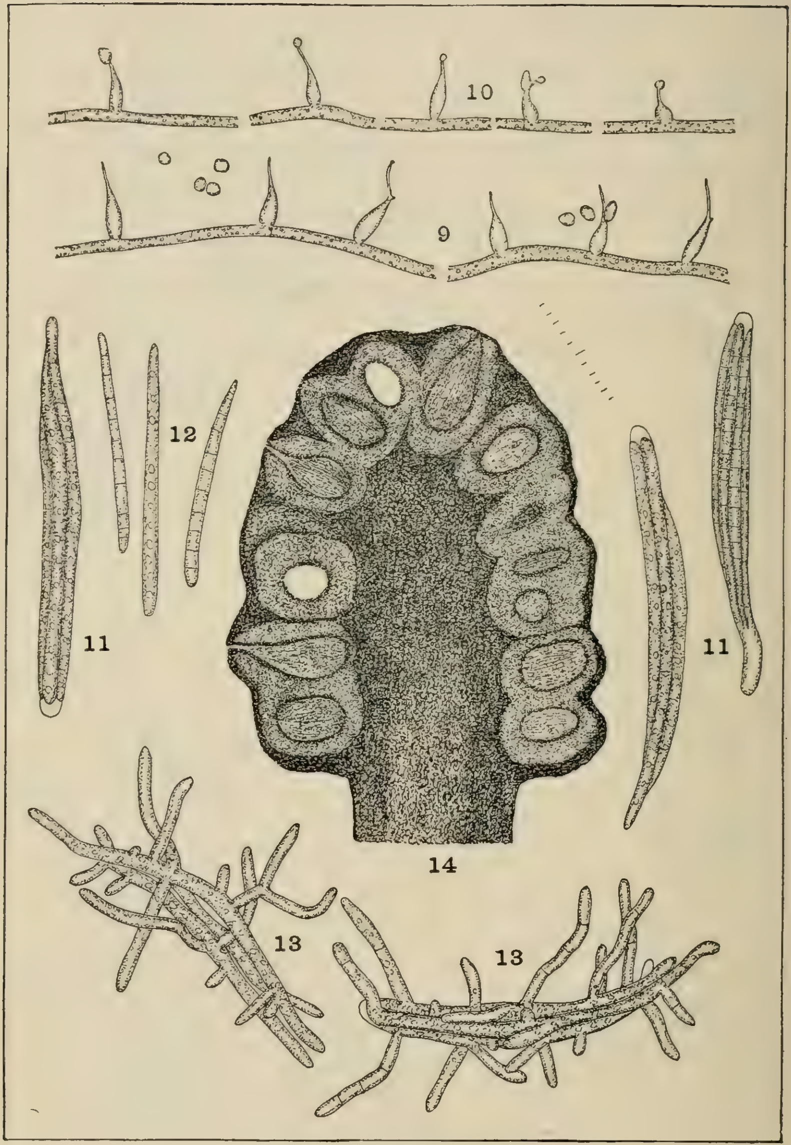

PLATE II.—Cordyceps clavulata.

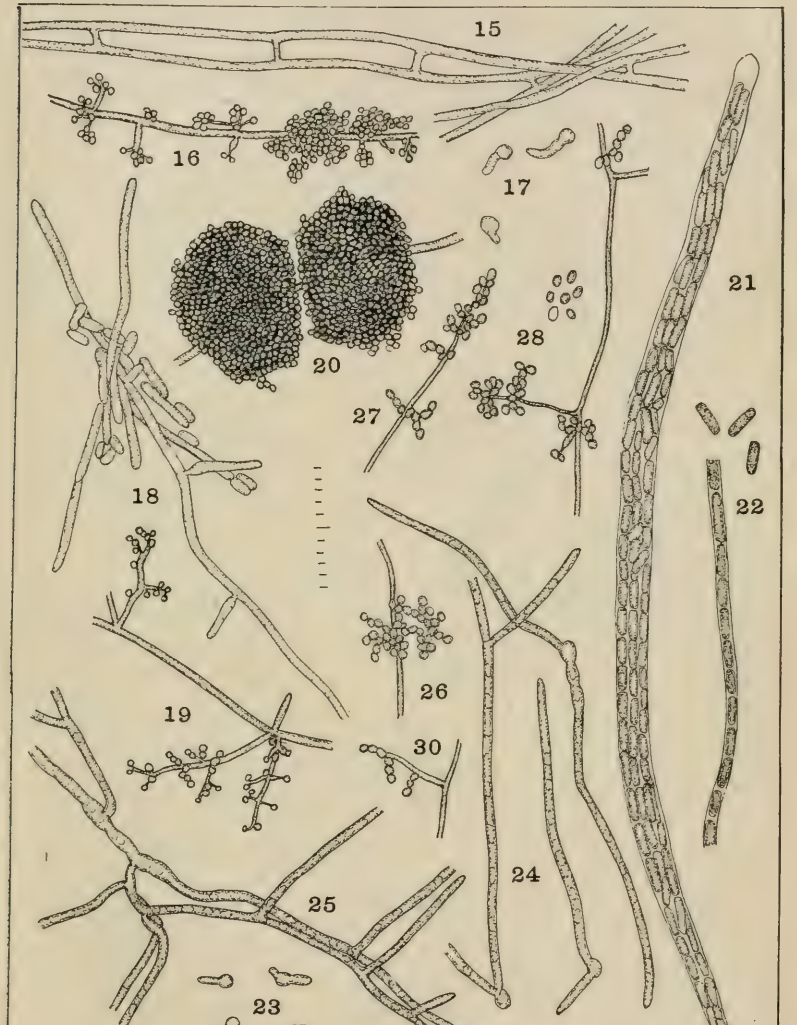

PLATE III.—15-20, Isaria vexans ; 21–22, Cordyceps militaris var ; 23–30, Isaria densa.

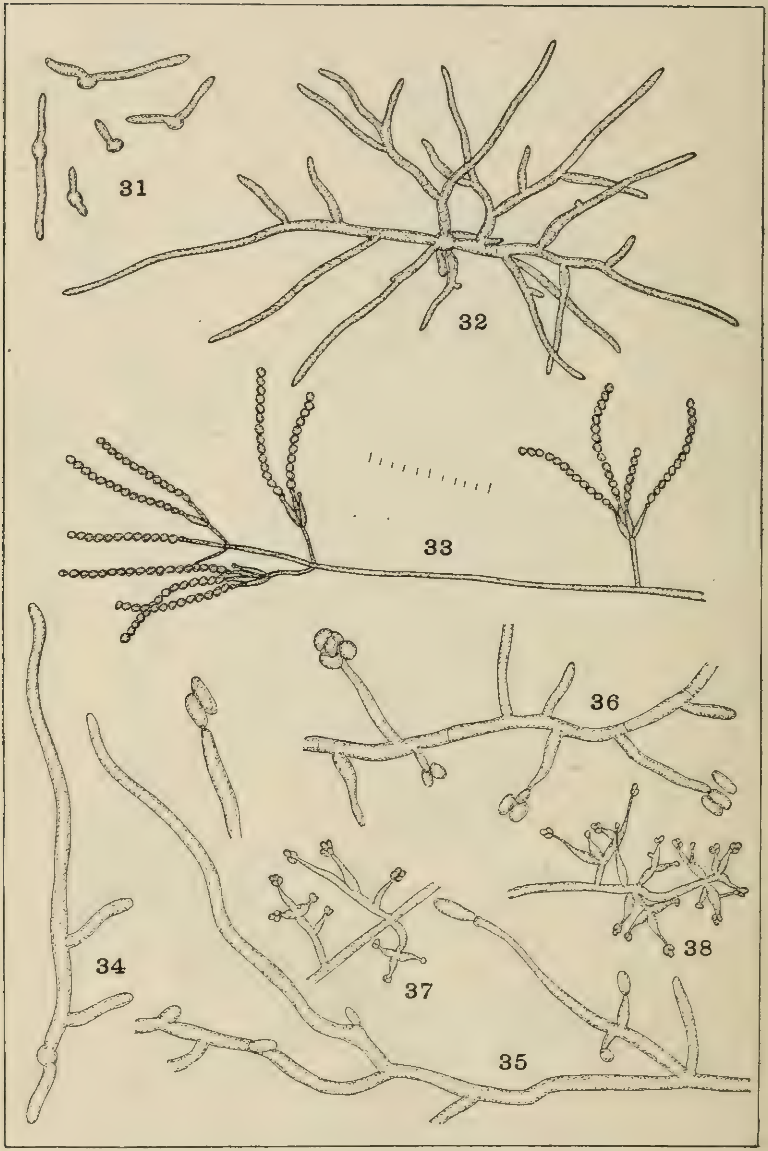

PLATE IV.—31–33, Isaria farinosa ; 34–38, Sporotrichum minimum.

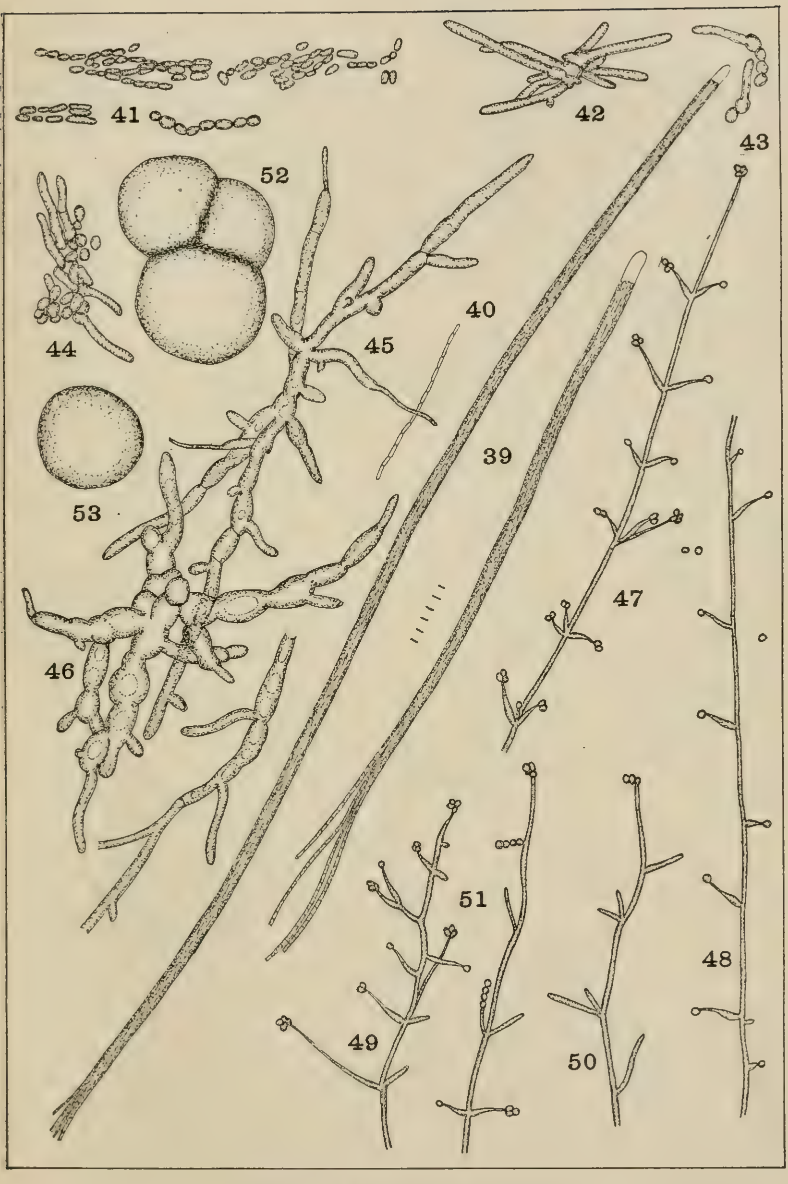

Plate V.— 39-53, Cordyceps militaris.

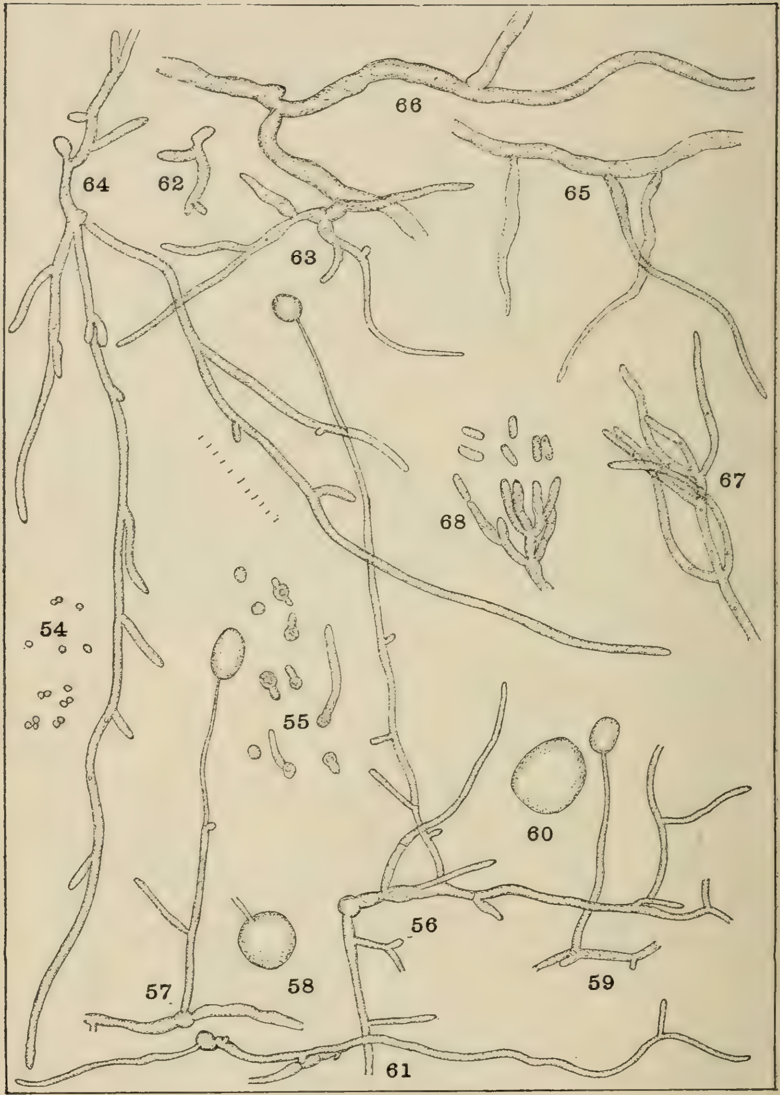

PLATE VI.—54-61, Cordyceps melolonthæ ?; 62-68, Isaria anisopliæ.

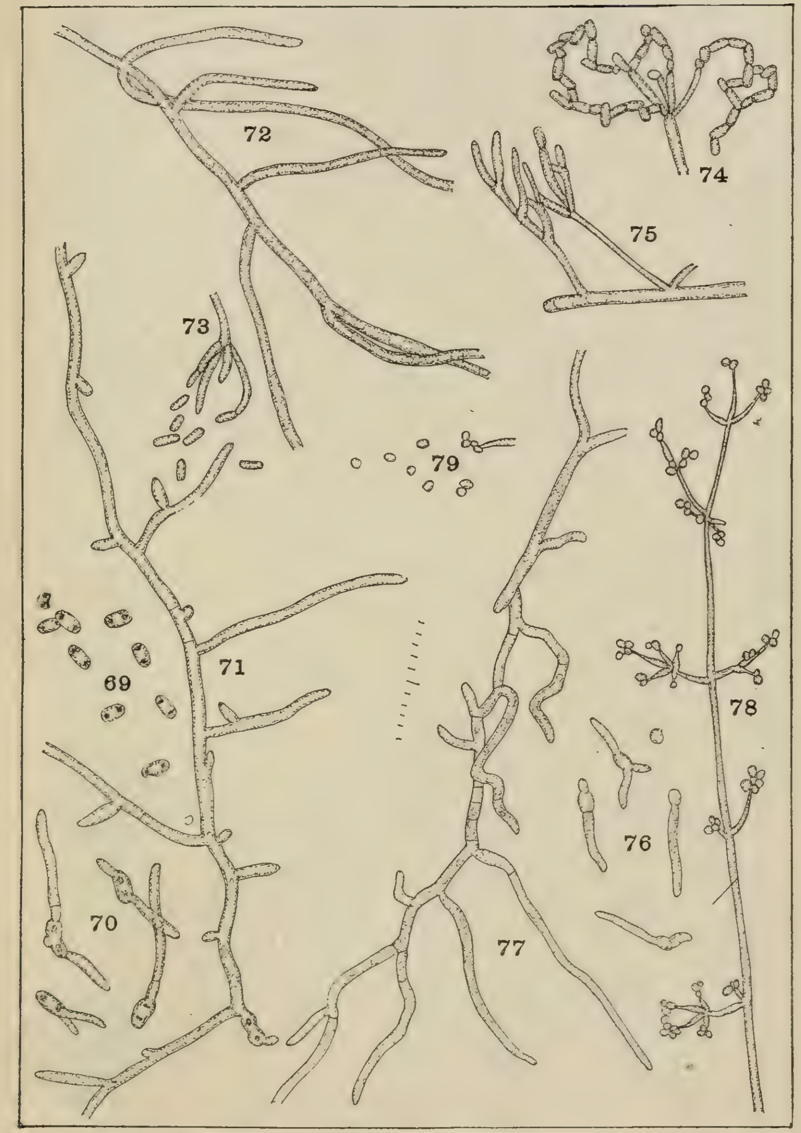

PLATE VII.—69-75, Isaria anisopliæ var. americana; 76-79 Isaria tenuipes.

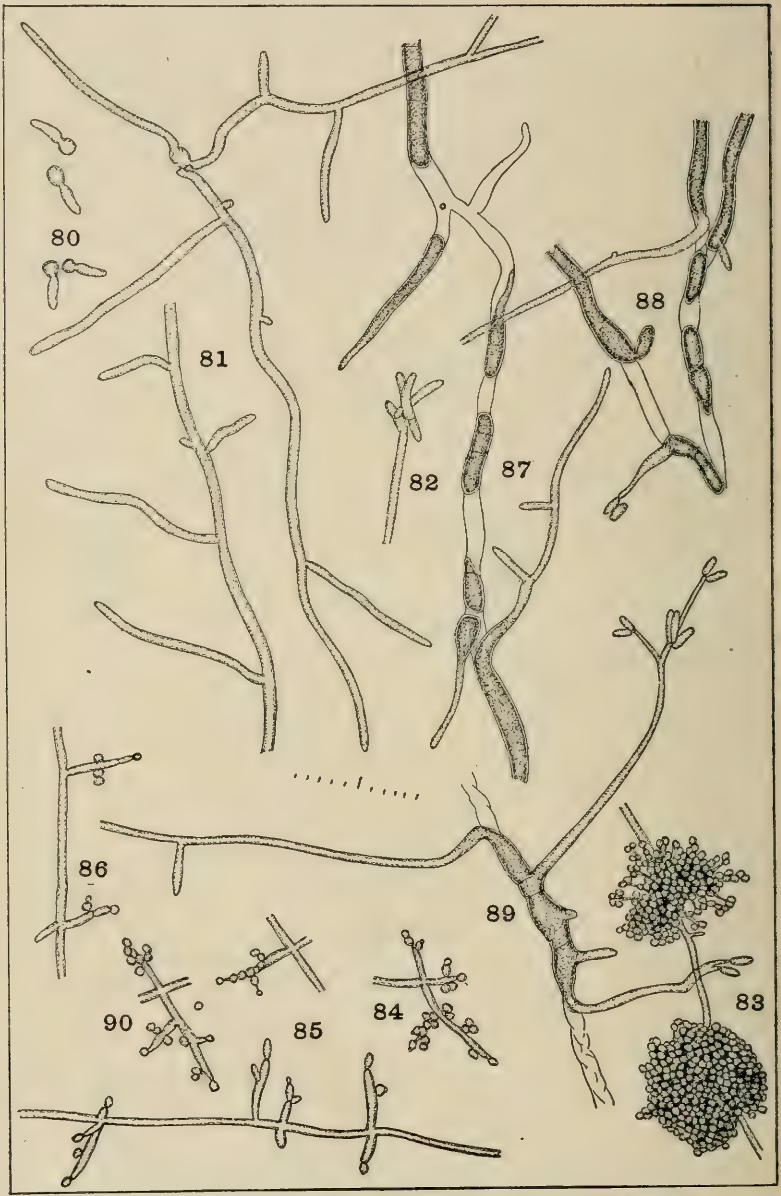

Plate VIII.—80-90, Sporotrichum globuliferum. From carabid beetle.

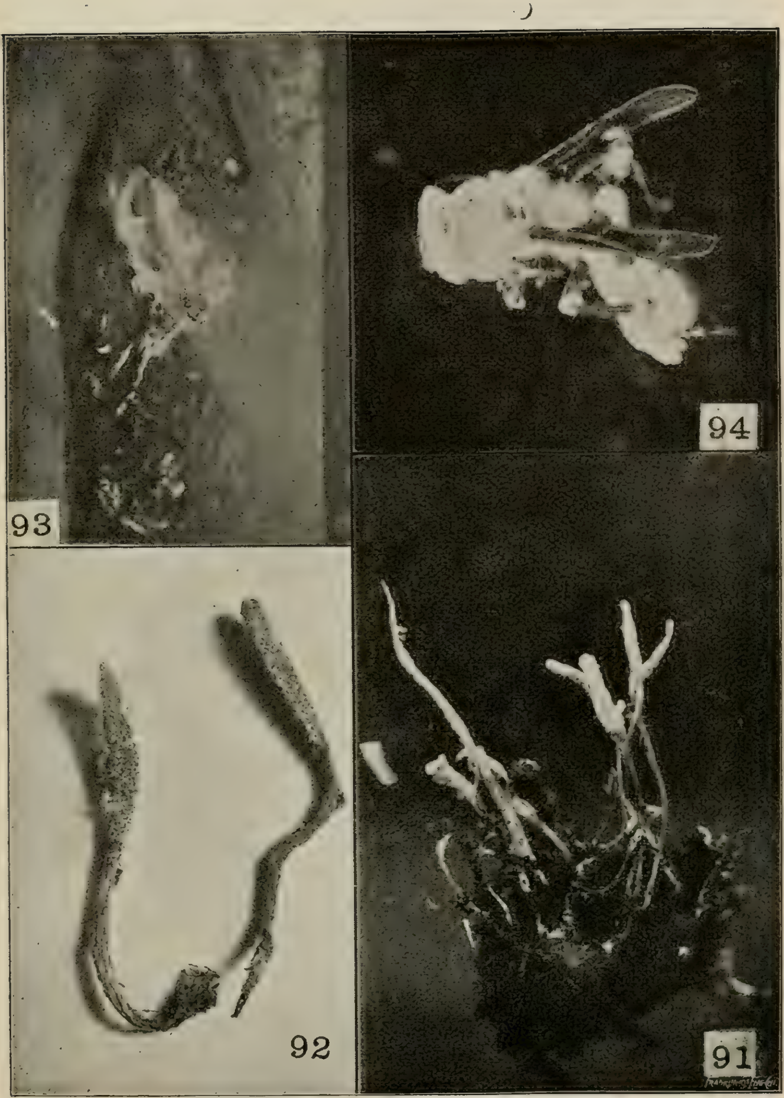

Plate IX.— 91, Isaria farinosa; 92, Cordyceps militaris; 93, Isaria farinosa; 94, Sporotrichum globuliferum (Isaria sp ?).

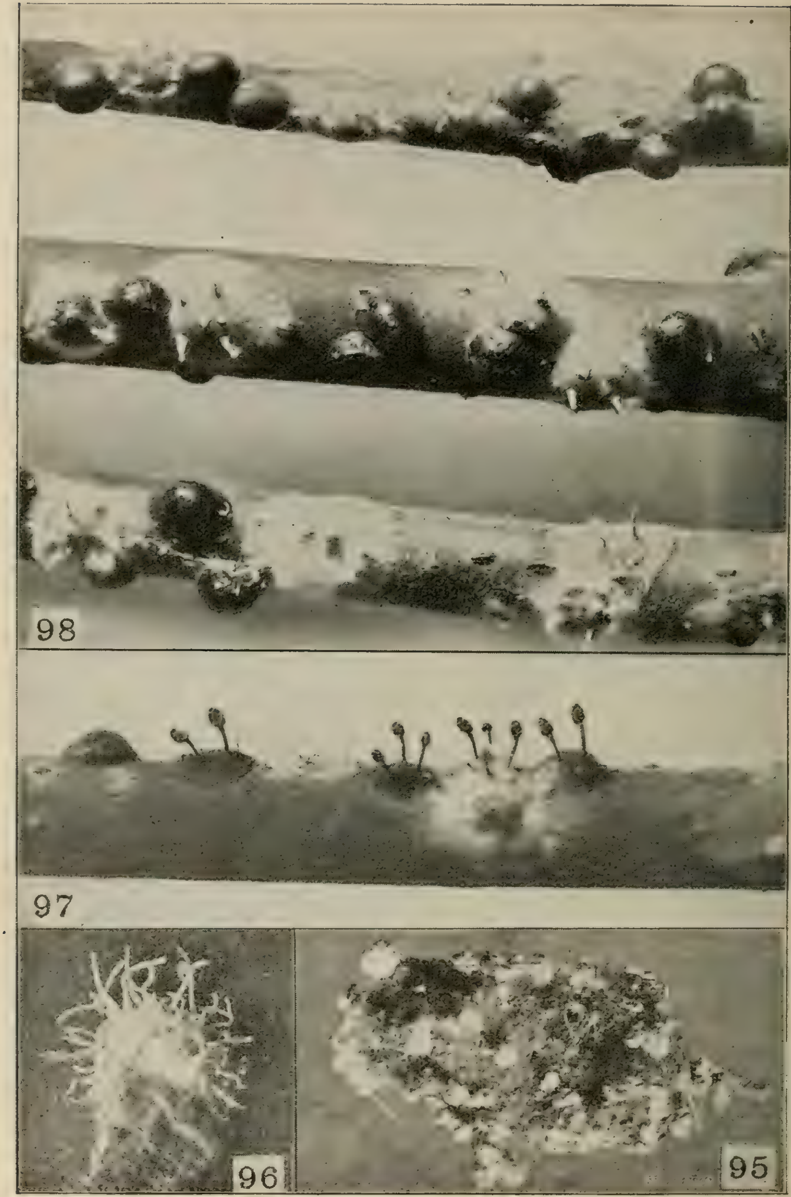

PLATE X.—95, Cordyceps melonorthæ? conidial stage; 96, Isaria arachnophila; 97, 98, Cordyceps clavulata.

99

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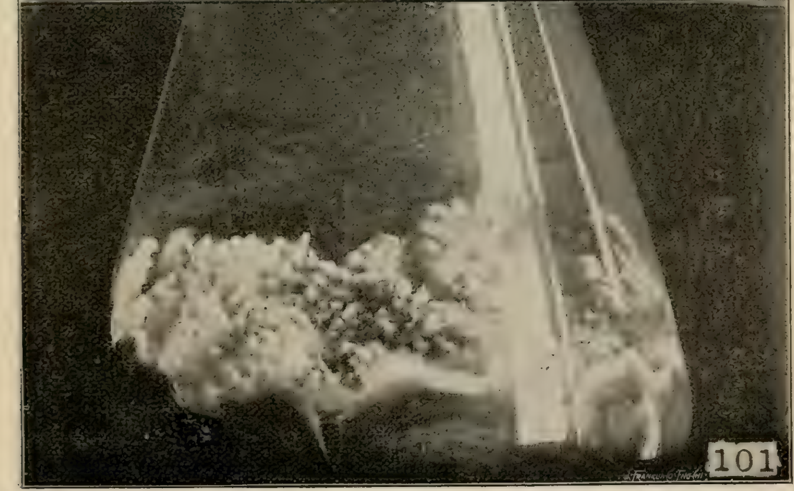
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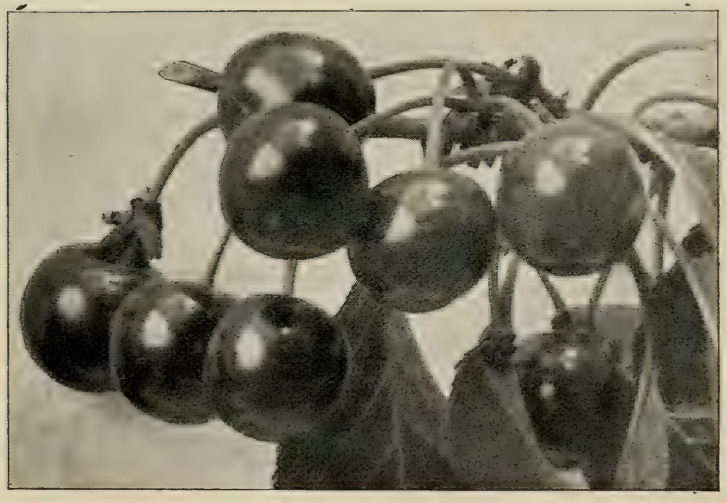
PLATE XI.—99, 100, Isaria teniupes; 101, Isaria vexans.

BULLETIN 98—July, 1895.

Cornell University—Agricultural Experiment Station.
HORTICULTURAL DIVISION.

CHERRIES.



Louis Phillippe. Page 477.

By L. H. Bailey and G. H. Powell.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in Western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. On the Effect of Feeding Fat to Cows.
93. The Cigar-Case Bearer.
94. Damping-Off.
95. Winter Muskmelons.
96. Forcing-House Miscellanies.
97. Entomogenous Fungi.

On account of the technical nature of Bulletin 97, only a limited edition was printed for the use of Experiment Stations and Exchanges.

98. Cherries.

CORNELL UNIVERSITY,
ITHACA, N. Y., *July* 10, 1895.

The Honorable Commissioner of Agriculture, Albany:

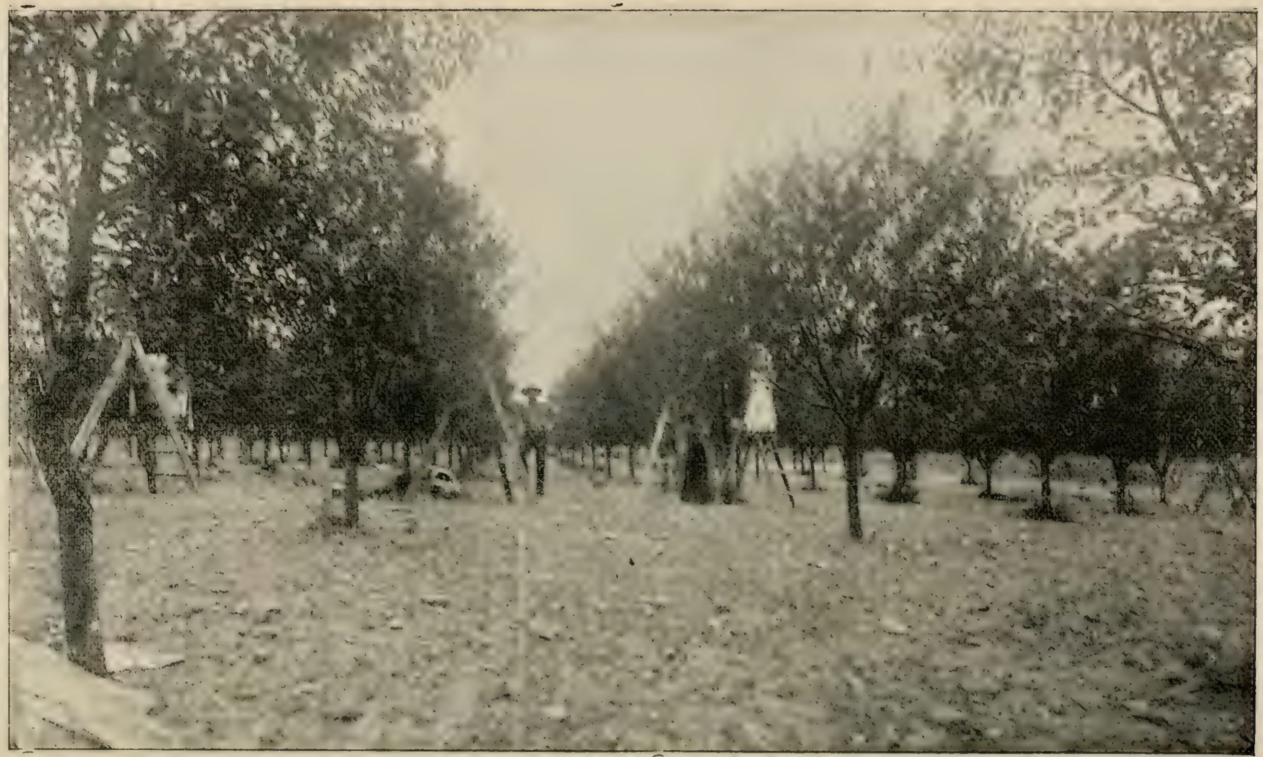
SIR.—The following account of cherry growing, written with particular reference to western New York conditions, is submitted for publication under Chapter 230 of the Laws of 1895. The older cherry plantations of the State were seldom anything more than scattered settings along lanes and roadsides, and about farm buildings. Most of these old trees have now passed their prime. In very recent years a new interest in cherry growing has been awakened by the demand from canning factories, and it has no doubt been stimulated, also, by the abundant sale of California cherries throughout the east. Sweet cherries are yet scarcely planted in western New York in orchard blocks, although there is every reason to believe that there is profit in the fruit if planters are careful to inform themselves concerning it. Sour cherries, however, are now planted to an important extent, particularly about Geneva, and the acreage is bound to increase. The pack of canned sweet cherries is still larger than that of sour cherries in western New York, in average years. The scattered plantings make uncertain crops, and canners can not buy as confidently as they could if there were more continuous plantations. Consequently the pack varies much from year to year. A normal pack for the Fifth Judicial Department may be considered to be nearly 100 tons of sour cherries and 150 tons of sweet cherries.

The literature of the whole subject of cherry growing is so meagre and so unsatisfactory, that I have taken much pains to ascertain the best methods and varieties for western New York. The chapter upon sweet cherries is contributed chiefly by G. H. Powell, Fellow-elect in Horticulture in Cornell University, who, with his father, George T. Powell, has had much experience with sweet cherries, and who, during last summer and this, has been employed as a special agent under the Laws designed to extend horticultural knowledge in the Fifth Judicial Department of the State. The other chapters are contributed by myself.

A full account of the native dwarf cherries will be found in our Bulletin 70.

L. H. BAILEY.

All the pictures of cherries in this Bulletin are made from life (except fig. 79) and they show the fruits exactly natural size. To the untrained eye, however, pictures look smaller than the objects from which they are made.



77.— Montmorency Cherries at 9 years. (7 years planted). C. K. Scoon, Geneva.— Tilled, fertilized, pruned, and sprayed.

Cherries.

I. CLASSIFICATION OF THE CHERRIES.

1. *The Horticultural Groups.*

Before proceeding to a discussion of the general subject in hand, it will be necessary to define the terms and classification which are used throughout this paper. The cherry is a perplexingly variable subject, and classification of the different types is much confused. In this account, I have conceived the cultivated tree cherries to be derived from two ancestrial species, the Sour Cherries (*Prunus Cerasus*), which are characterized by a diffuse and mostly low round-headed growth and a habit of suckering from the root, flowers in small clusters from lateral buds and generally preceding the leaves, the latter hard and stiff, light or grayish green and rather abruptly narrowed at the top into a point, the fruit roundish and always red, the flesh soft and sour; the Sweet Cherries (*Prunes Avium*), with tall-growing, erect habit and bark tending to peel off in birch-like rings, flowers flimsy, in dense clusters on lateral spurs and appearing with the leaves, the latter large and more or less limp and gradually taper-pointed, the fruit variously colored, spherical or heart-shape, the flesh either soft or hard and generally sweet.

The Sour Cherry class includes two general types:

1. *Amarelles*, with pale red fruits, which are generally flattened on the ends, and an uncolored juice. Here belong the Montmorency, Early Richmond and their kin. (The term Amarelle, from the Latin for *bitter*, is used by the Germans for these light-colored and white-juiced cherries, and it is the best term which I know for adoption in America. In France, however, it appears to have a less definite application.— See *Leroy*, *Dictionnaire de Pomologie*, v. 163. If this term is not acceptable, then I should choose *Kentish*, to designate this group of cherries.)

2. *Morellos or Griottes*, with very dark red fruits, which generally vary from spherical to heart-shape, and a dark colored juice includes the various Morellos, Ostheim, Louis Phillippe, and the like. (The word Morello is from the Italian, meaning *blackish*.

Griotte is a French word, and was originally applied to these fruits because of their dark red brown color.)

The Sweet Cherry group is represented in this country by four types:

1. *Mazzards* (*Merisier* of the French), small fruits of various shapes and colors, represented by miscellaneous and inferior seedlings of the Sweet Cherry species. Mazzard trees are common along roadsides and in the borders of woods, where the seeds are scattered by birds. Mazzard seedlings, imported from Europe, are much used as stocks by nurserymen.

2. *Hearts or Geans*, with a soft-fleshed heart-shape fruit, represented by the Governor Wood, Black Eagle, Black Tartarian and the like. (The word Gean—French *guigne*—is an old name for the cherry, ultimately probably of Greek origin.)

3. *Bigarreaus*, hard-fleshed, or crackling cherries, mostly of light color and heart-shape, comprising Windsor, Napoleon, Yellow Spanish, and others. (The word Bigarreau is French, sometimes anglicized as *bigaroon*, and it is applied to these fruits probably because of their *mottled* or *streaked* appearance. The typical bigarreaus are light red upon the sunny side, and whitish or lemon-yellow on the reverse.)

4. *Dukes* differ from the heart cherries chiefly in having an acid or subacid fruit. Here belong the May Duke, Reine Hortense, Belle de Choisy and a few other sorts. Horticulturists, and even botanists, persist in classing the Dukes with the true sour cherries, but there is nothing to warrant such association beyond the mere incidental sourness of the fruit. The habit of tree, characters of flowers, leaves, and even of the fruits, are clearly those of the sweet cherry type. Even the sourest of them are sweet as compared with the true sour cherries, and there is every gradation from the type of May Duke to the typical Hearts. (May Duke is a corruption of *Mèdoc*, a district in southern France, whence the variety is said to have come. In France, the leading Dukes are known under the name of *Royales*, Jeffrey's Duke being called *Royale*, and May Duke *Royale hâtive*.)

2. *The Botanical Classification.*

There are few plants of which the botanical nomenclature is more perplexingly and delightfully mixed than the cultivated cherries. They were already widely grown and immensely variable when the science of descriptive botany was born. Nearly every botanist who has taken up the study of them has arrived at a new conclusion respecting the number of the original species from which they have come. The extreme opinions are represented on the one hand by Bentham (British Flora), who accepts but a single species, and on the other by M. J. Roemer (Synopsis Monographicæ), who makes thirteen species. It is consoling to know that Bentham's estimate can not be reduced, and it is certain that Roemer's species can not be distinguished. The oldest De Candolle (Prodromus) refers the cherries to four species, but he made the usual mistake of classing the Dukes and Morellos together; and it is also true that some of his species are indistinguishable in the absence of fruit. If one desires to recognize the most permanent horticultural differences and if he wishes at the same time to be able to distinguish the species which he makes, he will accept the division into two species, as proposed by Linnæus. These are *P. Cerasus*, the sour cherry type, and *Prunus Avium*, the sweet cherry type. I believe that these represent true original sources of the garden cherries.

It would be unwise to attempt a complete synonymy of the cherries in this place, but the following arrangement will explain most of the perplexities with which the student will meet:

I. PRUNUS CERASUS, Linnæus, Sp. Pl. 474 (1753). SOUR CHERRY.
P. acida Ehrhart, Beitr. v. 162.
Cerasus vulgaris, Miller, Gard. Dict 8th ed. No. 1.
C. Caproniana, DC. Fl. Fr. iv. 482 (Excl. Dukes).
C. acida, Beehst. Forstb. 161.
C. austera, Roemer, Syn. Monogr. iii. 75, in part.
C. tridentina, Roemer, Syn. Monogr. iii. 76.
C. Rhexii, Van Houtte, Fl. Serr. 2d ser. vii. 159.

Of the nine forms which De Candolle dignifies with Latin varietal names two are important in the present discussion, viz.: Var. *Montmorencyana*, including the Amarelle types (and also, wrongly, the May Duke), and Var. *Griotta*, including the Morellos and Ostheim. Roemer refers the Amarelles or white-juiced cherries to *Cerasus acida*, and the Morellos to *C. Caproniana*. His *C. austera* compares various sour varieties and the Dukes.

II. PRUNUS AVIUM, Linnæus, Fl. Suec. 2d ed. 474. (1755 SWEET CHERRY.)

Prunus Avium itself is held to represent the mazzard type.
Cerasus Avium, Moench Meth. 672.
C. rubicunda, Bechst. Forstb. 160, 355.
C. pallida, Roemer, Syn. Monogr. iii. 69.

Var. JULIANA. HEART OR GEAN CHERRIES.
Cerasus Juliana, DC. Fl. Fr. iv. 483.
C. Heaumiana, Roemer, Syn. Monogr. iii. 69.

Var. DURACINA. BIGARREAU CHERRIES.
Cerasus Duracina, DC. Fl. Fr. iv. 483.
C. Bigarella, Roemer, Syn. Monogr. iii. 69.

Var. REGALIS. DUKES.
Cerasus regalis (*præcox* and *Communis*), Poiteau and Turpin, Traité des Arbres Fruitiers, 123.

II. SOUR CHERRIES IN WESTERN NEW YORK.

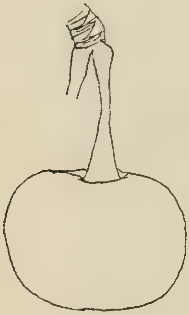
The growing of sour cherries in western New York is largely confined to two varieties, the Montmorency and English Morello, and it is not yet fully determined which of the two is the more profitable in the long run. The preference has generally been given to the English Morello, as it bears younger than the other, and its dark colored and very acid flesh have made it popular with the canning factories. Just now, however, the canners are calling for the Montmorency in preference, for, whilst not so sour as the other in the natural state, it "cooks sour," and the Morello is apt to develop a bitterish or acid taste in the cans. The Morello is also much subject to leaf-blight, whilst the Montmorency is almost free from it; and the Montmorency is a stronger and more upright grower. The present drift is decidedly towards the Montmorency. The two varieties complement each other, however, for the Montmorency is about gone by the time the other is fit to pick.

This Montmorency of western New York is seen natural size in Fig. 78, and an orchard of it, seven years from the planting, is shown in Fig. 77, at the beginning of this bulletin. It is a very light red, long-stemmed cherry, broad, and flattened on the ends, the flesh nearly colorless and only moderately sour. The tree is an upright vase-like grower.

This variety is supposed to be the *Montmorency ordinaire* of the French, but Leroy, the leading contemporaneous French authority (*Dictionnaire de Pomologie*), knows only one variety under this name, which is sold by "some nurserymen," and it is the same as the variety *Hâtive* (i. e., Early), which is very like the cherry known in this country as the Early Richmond. The real *Montmorency* Leroy considers to be indentical with the Early Richmond of English and American writers, although his description and figure of it make such association impossible. As nearly as I can determine, the Montmorency of western New York is the one which Leroy figures as Montmorency, and not the *Montmorency ordinaire*. There is still a third French Montmorency, the *Montmorency à gros fruit* (i. e., the Large-fruited Montmorency), better known as Short-

78.—Montmorency.

stemmed Montmorency (*Montmorency à courte queue*), and Gros-Gobet; in England and America it is often called Flemish Cherry or Flemish Montmorency. (See Downing, 480; Leroy, v. 365; Lauche, Deutsche Pomologie, Kirschen, 19.) This variety is characterized by a very short stem, which at once distinguishes it from other cherries. Leroy's diagram of the fruit of this Large-fruited Montmorency is here reproduced (Fig. 79). I do not know that this variety now exists in this country. It was early imported, with other sorts, by Ellwanger & Barry. They grew it as *Montmorency à courte queue*, and applied the name *Montmorency Large-fruited* to another cherry, which W. C. Barry tells me was superior to the common Montmorency in quality, but which proved to be unproductive. So it happens that the Montmorency Large-fruited of western New York is not the French variety of that name. It should be remarked, in passing, that the standard and monumental work of Poiteau (Pomologie Francaise) contains no such varieties or synonyms as *Montmorency ordinaire* and *Montmorency à gros fruit* (large-fruited), but Leroy, whom I have quoted, has recently (1877) made an elaborate attempt to untangle the synonymy.



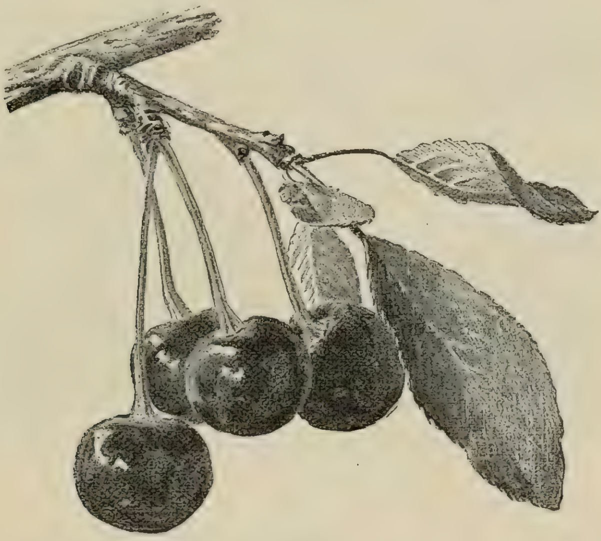
79. — Large-fruited or Short-stemmed Montmorency. (After Leroy.)

80.—Early Richmond.

Early Richmond (Fig. 80) is the only other Amarelle, or white-juiced cherry, which is grown to any extent in western New York, and this is not very valuable. Its flavor and quality are poor, the fruit is soft and small, and it is so early that it competes with the late strawberries. It is considerably used by canners, but the better cherries are bound to drive it out.

Amongst the Griottes, or red-juiced cherries, three have gained some notoriety in western New York, — the Ostheim, Louis Phillippe, and Morello.

The Ostheim is a very productive variety, ripening about a week after Early Richmond, but it is too small and too early to be valuable for general cultivation here. As compared with Early Richmond, it is darker red, rounder and somewhat smaller, the stem longer, stouter and straighter, flesh and juice dark red and less acid. (Compare Figs. 80 and 81.) Hangs long on the tree.

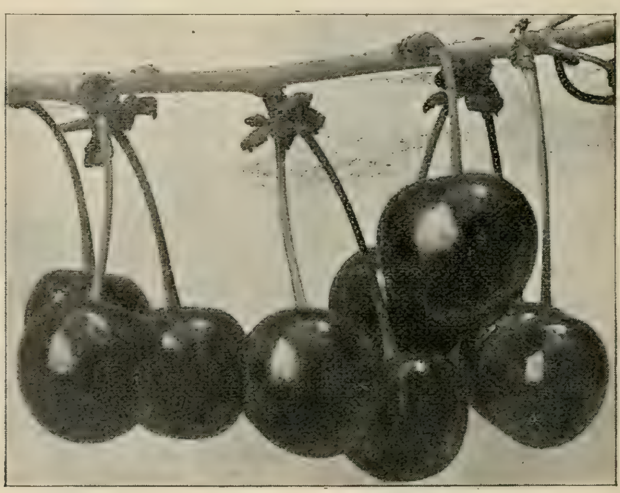


81.— Ostheim.

Louis Phillippe (see page 467) is one of the best of all the sour cherries, and it would no doubt be generally grown were it not for the prevalent opinion that it is unproductive. C. W. Stuart, of Newark, who has had a long experience with this cherry, tells me that it is a profuse bearer when the tree has attained some age, and he thinks that it might be more freely planted with profit. It seems to be particularly attractive to the curculio, and some growers regard this as the cause of its unproductiveness. The fruit is nearly spherical, about the size of Montmorency and rather sourer, very dark red in skin and flesh, of very best quality. Ripens with Montmorency. I do not know if the Louis Phillippe of western New

York is properly named or if there are two varieties of the same name. Leroy makes the name a synonym of Reine Hortense, a very different fruit.

The Morello (Fig. 82), variously known as English, Large, Dutch and Ronald's Morello, is nearly two weeks later than Montmorency, a bushy and finally a drooping grower, with medium-sized, roundish or round-cordate fruits which become red-black when fully ripe. Flesh very dark, much sourer than the Montmorency. In western New York the Morello harvest begins from the 8th to the middle of July.



82.—English Morello.

The cherry orchard.— A strong, loamy soil, and one which is retentive of moisture, is the most suitable for sour cherries. The fruit contains such a large amount of water that it is necessary to save the moisture of the soil to the greatest possible extent. Dry clay knolls produce cherries of less size and of inferior quality than the moister depressions between them. Very early and thorough cultivation is essential to this conservation of moisture, and the tillage should be continued at frequent intervals until the fruit is about ripe. In order to be able to cultivate the soil at the earliest moment in the spring, the land should be either naturally or artificially well drained. The crop of even the Morellos is off the trees in July, so that there is abundant opportunity to sow a catch crop on the orchard for a winter cover, if the manager so desires. A variety of plants may be used for this cover. The best is probably crimson clover, particularly if the orchard needs more nitrogen or growth; and if American grown seed is sown by the middle of August in a well prepared soil, the cover will probably pass the winter safely. Other plants which may be used for cover are rye, winter wheat, vetch, field pea, sowed corn, millet and buckwheat. Of these, only the two first will live through the winter and grow in the spring. In using cover crops which survive the winter, it is very important that they be turned under *just as soon as the ground is dry enough in spring.* As soon as the plant begins to grow it evaporates moisture and dries out the soil; and it is more important, as a rule, to save this moisture than it is to secure the extra herbage which would result from delay. This is especially true with the sour cherry, which matures its product so early in the season, and which profits so much by a liberal and constant supply of soil moisture. Plowing can also be begun earlier on land which has a sowed crop upon it, because of the drying action of the crop. The fertilizers which give best results with other orchard fruits, may be expected to yield equally good returns with the cherry. (See Bulletin 72.)

It is an almost universal fault to plant cherry trees too close together. The Montmorency should not be planted closer than 18 feet each way, in orchard blocks, although it is often set as close as 12 feet. The English Morello is a more bushy grower and may, perhaps, be set as close as 16 feet with success; but I believe that even this variety should stand 18 feet apart. The sour cherry orchards in western New York are yet so young that the evil effects of close planting have not yet been made apparent. I find, however, that nearly every shrewd orchardist who has had experience with these fruits is convinced that the general planting is too close.

Cherries are usually set when two years old from the bud. The sour varieties are propagated both upon Mazzard and Mahaleb stocks, chiefly the latter, but the comparative merits of the two are not determined. The tops are started about three or four feet high, and the subsequent pruning is very like that given the plum. If the young trees make a very strong growth and tend to become top-heavy, heading-in may be practiced; but this operation is not considered to be necessary after the trees begin to bear. Cherry trees require less attention to pruning than apple trees and peach trees do.

The orchard shown in Fig. 77 may be taken as a model, except that the trees are too close together.

The English Morello will bear a fair crop the third year after setting, if two-year trees are planted. The Montmorency is a year or two later in coming into bearing. The Montmorency, partly because of its larger growth, produces much more fruit than the other, when it arrives at full bearing. Individual trees of Montmorency at six years and upwards may bear from 30 to 75 pounds of fruit; but Mr. Scoon considers 8 to 10 tons of marketable fruit to be an excellent crop on an orchard of 800 Montmorencys eight years planted—that is, an average of 20 to 25 pounds to the tree. The Morellos, because of their dark color, usually sell better than the Montmorency in the open market, but the reverse is now generally true if the crop is sold to canning factories. This year the factories have paid five and six cents a pound for Montmorencys. It is easy to figure the proceeds of an acre. At 18 x 18 ft. an acre will comprise about 130 trees. If, at eight years, they yield 20 pounds each, the crop would amount to 2,600 pounds, which, at 5 cents, means $130. This is a conservative estimate. Benjamin Kean, Seneca, has 200 Montmorency trees six years set. He has had three crops, one of 1,400 pounds, one of 3,000 pounds, and one 3,100 pounds. He sold his entire crop this year for 5 cents, making a gross income of $155. His trees are set 10 x 12 ft., which allows about 360 to the acre. In other words, a crop which sold for over one hundred and fifty dollars was taken from less than two-thirds of an acre. The soil, in this case, seems to be unusually well adapted to this cherry and the crops have, therefore, been excellent; but, on the other hand, part of the crop was destroyed this year by curculio. C. H. Perkins, Newark, has 35 trees, 8 and 12 years old, all Montmorency. "They bear," he writes, "from 2,000 to 3,500 pounds of cherries per year, and the average price we get for them is 6 cents. They net us from $100 to $175 a year. They are the most regular and sure cropper of any fruit we have ever tried to grow, and the fruit always finds a ready market at a good price." The Maxwell orchard at Geneva yielded over 11 tons, Montmorency, this year, from 800 trees.

My reader will now want to order enough cherry trees to plant his farm. But he should go slow. It may be laid down as a principle that no crop will bring uniformly great rewards over a series of years. These results with sour cherries are obtained only when all the conditions are present, such as the proper soil, excellent care and fertilizing, ability to secure pickers, and access to good markets. One could probably not rely upon the open market for the disposal of a very large planting of sour cherries. He should have access to one or more canning factories. It is a fact that more than half of all the orchards, of whatever kind, which are conceived in expectation and planted with enthusiasm, turn out to be profitless. The fault lies somewhere under the owner's hat. Persons who fail to grow other fruits with profit, may also expect to fail with cherries. Yet I know of no fruit which, upon the testimony of both producers and consumers, offers a greater reward than sour cherries. The public seems to have acquired a taste for the canned product, and there is every indication that this demand will increase.

The labor of picking cherries, which is a bugbear to so many who would like to plant the fruit, is really no more onerous than the picking of raspberries or currants. If one lives where pickers cannot be had with certainty, and in sufficient numbers, cherries should not be planted. Parties who hire pickers by the piece, pay three-fourths cent or a cent a pound. The trees must be gone over twice, at intervals, and generally three times, and it is important that all those fruits which are ripe, and no others, should be secured at each gathering. It is more difficult to see that this is done on cherry trees than on berry bushes, and for this reason some growers prefer to hire pickers by the day. When picking for canners, the fruit may be allowed to become much riper then when it is to be sold in the open market, and it is not necessary to exercise so much care to preserve the stems upon the fruits. The English Morello drops easily when ripe, and growers sometimes shake off the cherries — if designed for canning — onto sheets or, if the trees are small, into a Johnson curculio catcher. If cherries are carefully hand-picked for the general market, the stems being left on, a pound of fruit measures about a quart and a quarter, but as the fruit is generally picked for canning, a pound is about a quart.

Insects and diseases are not serious upon the sour cherries. The curculio does not often attack the midseason and late varieties — such as Montmorency and Morrello — seriously, particularly if the number of trees is somewhat large. In occasional years, however, this insect becomes a scourge. The grower must watch his fruits closely after the blossoms fall, and if the curculio injuries become alarming, he must catch the insects by jarring them onto sheets. There are those who declare that they attract the curculio away from the cherries by planting plum trees in the cherry orchard, but I greatly doubt the efficiency of this procedure. A complete account of the curculio may be expected in a forthcoming bulletin.

The leaf-blight or shot-hole fungus (*Cylindrosporium Padi*, or *Septoria cerasina*, the same which attacks the plum), is often a serious enemy, particularly upon the English Morello. The leaves begin to assume a spotted character, generally before the fruit is picked, they soon turn yellow, and they fall prematurely. Thorough spraying with Bordeaux mixture is as efficient in holding the leaves on the cherry as it is on the plum. The trees should generally be sprayed twice between the falling of the blossoms and the coloring of the fruit. If the cherries are more than half grown when the last spray is applied, the ammonical carbonate of copper may be used in place of the Bordeaux, to avoid discoloring the fruit. But it is doubtful if the last spray should be delayed until this time. It may be necessary to spray once after the fruit is off.

A thin grayish powderly mildew (*Podosphæra Oxyacanthæ*) frequently attacks the fruits and leaves of the sour cherries, particularly when the trees are overshadowed by larger trees or buildings. I have never known it to be serious upon the fruit, as it appears about the time the fruit is ripening, covering the cherries with a very delicate coat, like dust. In this case a late spraying with ammonical carbonate of copper would certainly be effective. The only emphatic injury which I have ever seen from this fungus upon cherries occurs after the fruit is off, when it may attack the ends of the shoots, checking the growth. At this time, if the injury threatens to be serious, Bordeaux mixture may be used.

The black-knot, which seriously invades sour cherry trees, is fully treated in our Bulletin 81.

III. THE SWEET CHERRY INDUSTRY.

Unlike most other fruits, the sweet cherry has never attained a prominent position as a horticultural industry in western New York. There is not a single orchard of it west of Albany, so far as I know. Along the Hudson, however, there are three or four orchards. It is from the few trees scattered on every farm throughout the State, that the cherry crop is mostly harvested. It should not be concluded, however, that the smallness of the industry follows from a lack of appreciation on the part of New York people of this most luscious fruit. It is due to the fact that the cherry is one of the most difficult crops to handle and market successfully, because of its exceedingly delicate character and its susceptibility to the fungus, which causes the brown rot. This fungus spreads so rapidly on the ripening fruit, that a promising crop to-day may be half rotted to-morrow. The comparative ease of handling and marketing a grape, an apple or a pear crop have made those fruits universally popular, while the cherry has lain in obscurity.

The cherry is one of the most popular dooryard fruits, and its hardiness, its vigorous spreading or ascending branches, its upright form, which often attains the height of forty to fifty feet, and its luxuriant, soft drooping foliage make it a most desirable tree for ornamental and fruit-bearing purposes. Amongst the strongest recommendations of the cherry are its hardiness and the fact that it bears annually when properly treated. The trees begin to grow very early in the season, and the fruit of most varieties is harvested by July 1st, thus leaving the tree sufficient time and energy to perfect the fruit buds for the coming year, and if the wood ripens during the fall the mercury can fall to 20° below zero without injury to the coming crop. There seems to be a general inquiry among fruit growers and farmers concerning the care of cherry orchards, the most desirable varieties, the diseases, and methods of handling and marketing a crop. As these matters are more fully understood the cherry industry may be expected to reach a prominent position among the other horticultural industries.

Soil and location.—The cherry tree is a gross feeder and grows with surprising rapidity, the limbs of young trees sometimes increasing from four to six feet in one season. This characteristic of the cherry must not be lost sight of in selecting a site for the cherry orchard, for when too rapid growth takes place the trunks and large limbs split open, the sap exudes abundantly, little or no fruit is borne and the life of the tree is short. The cherry will grow in a variety of soils, even where other fruit trees will not thrive, but the ideal soil is a naturally dry, warm, mellow, deep gravelly or sandy loam, of good quality, containing sufficient humus to retain moisture and give lightness, but not enough to make the soil damp and heavy. If the soil is not naturally dry it must be well drained, for dryness is essential to success with the vigorous growing sweet cherries.

While more orchards are unproductive from a lack of plant food than from an excess, it is well to remember that the vigorous growing habit of the cherry lays it open to severe injury and unfruitfulness if the soil is too rich.

The ideal situation for the orchard is a high altitude which insures good atmospheric as well as land drainage and lessens the dangers from late frosts in the spring and from the rot. The cherry is an early bloomer, and it should be placed where the cold air at night will settle away from it, as injuries from spring frost frequently occur.

Distance of trees.—Since the cherry attains a large size, the limbs spreading twenty feet or more and the roots reaching a long distance, it must be given plenty of room, and I am convinced that 30 feet each way is the proper distance to set sweet cherries. I have seen trees 22 feet apart with their main branches interlacing, and the trees were allowed to assume a pyramidal form instead of a spreading habit. At 30 feet each way an acre contains 50 trees.

Pruning.—The cherry orchard will require little pruning after the first two or three years, and before that time the tree can be made to assume any desired form. I believe, however, that in general the pruning should be such as to give the tree a low spreading head with a trunk about four feet high and with the top built out on three to five main arms. We have pursued this method on the Windsor and other varieties and the trees, instead of growing in the usual spire shape, assume an apple-tree form. After the first two or three years no pruning is needed, except to remove dead branches and to keep superfluous branches from intercrossing.

The advantages gained from this form of tree are of great importance. First the body of the cherry tree is less likely to be injured from the hot sun, which causes it, especially on the side of the prevailing wind, to crack and split, exude sap and finally to die. The low spreading head shades the trunk and large branches and obviates this difficulty to a great extent. In western New York this trouble is not so serious as it is on the black lands farther west. A second advantage, of equal or greater importance, lies in the fact that, if allowed to grow upright, the limbs reach the height of thirty to forty feet in twenty-five years, making it very difficult to gather the fruit and to spray the trees. The bearing branches are always found towards the extremities of the limbs, and the time which men use in going up and down large ladders is of no small account to the fruit grower.

Cultivation.—A young cherry orchard should be given clean cultivation. Small fruits, like currants, raspberries or gooseberries or any others that require frequent cultivation, may be set between the rows for eight or ten years, but the bushes should be removed in the tree rows and opposite the trees at the end of the third year. No crop that does not require cultivation should ever be raised in the orchard. In general, the methods described in Bulletin 72 upon "The Cultivation of Orchards" should be followed.

At about five years old the trees begin to bear fruit of consequence, and at 10 years they give paying crops. As the orchard comes into bearing, the management of the soil will differ according to its nature, and the trees themselves should be the indicators of their treatment. Though there have been no experiments in the treatment of bearing cherry orchards, I believe that clean culture should generally be stopped by June 15th, or July 1st, so as to check growth and give the wood sufficient time to ripen. The advantages of this treatment are also pointed out in the Bulletin mentioned above. Whenever the growth becomes too luxuriant, it can be checked by seeding a year with clover.

A certain cherry orchard has stood in sod for fifteen years in an ideal soil and situation. The trees are making little growth and are filled with dead limbs, and while there was a heavy crop of cherries this year, the size was small, quality poor and one-half were rotting on the trees. In striking contrast was a neighboring orchard which had been ploughed lightly in the early spring and had had a harrow run over it once a week up to the middle of June, and although there had been a severe drought, the trees had made a good growth and were loaded with luscious fruit of large size. The latter orchardist believes that he can produce as large cherries as the Californians can, by high cultivation and the conservation of moisture the early part of the season. As a means of holding moisture, he is putting humus in the soil by cover crops and expects to check too luxuriant growth by seeding the orchard whenever it becomes necessary. While dryness is a universal maxim for the cherry, it is advantageous to conserve moisture during the development of the fruit, and the example furnished by this orchard convinces me that the fruit can be increased one-half in size by thorough light cultivation up to the middle of June.

Fertilizers.—The cherry probably requires as little fertilizers as any fruit grown. An occasional crop of crimson clover turned in will generally furnish sufficient nitrogen and improve the soil in other ways. Potash can be furnished in wood ashes or in a high grade muriate of potash, using 250 pounds per acre of a 50 per cent. muriate. This should be applied in the spring and harrowed in. Phosphoric acid may be applied in the same proportions in the form of bone compounds or in South Carolina or Florida Rock. In good soil, it is seldom that the cherry orchard needs heavy fertilizing if clean culture is practiced; the close observer can tell when to apply plant food by the action of the trees themselves.

Limits to the profitable age.—The cherry will live to a great age and bear fruit, there being records of such trees over a hundred years old. As the cherry industry is so small, and no great number of trees have been treated as an orchard for a long time, it is difficult to say just how long an orchard will continue to be profitable. This will depend largely on the variety. In general, I should say that thirty years is the limit to the most profitable age. After that time the trees become so large that the expense of picking the fruit and caring for the trees increases rapidly.

Handling the crop.—Before one goes into the sweet cherry industry as a business, it should be clearly understood that the cherry is a delicate fruit and more susceptible to injury from handling and from changes in the weather than the strawberry, and the industry should not be taken up unless plenty of good pickers can be obtained on short notice and unless desirable markets are within reach in eight or ten hours after the fruit is picked. It is one thing to raise a crop of fruit, but an entirely different thing to handle and market it successfully. These remarks apply with particular emphasis to the sweet cherry, because the crop has to be sold immediately when ripe and the delay of a day may mean the loss of the entire crop, as the commission men "slaughter" the sales when the fruit begins to go down. It is strongly recommended that the markets be thoroughly looked up and studied before one goes into the cherry business.

The first essential in handling a crop of cherries is to have the fruit picked with great care, the stem being left on each cherry, and only the stem touched with the fingers. The most desirable method of picking is in 8-lb. baskets, as in a larger package the bottom fruits are pressed too heavily. I saw delicate Tartarian and

Governor Wood picked in half bushel baskets this summer and then turned into 12-lb. baskets for shipping, and the grower wondered why his cherries got into market, which was only three hours away, in such poor condition! The handling of cherries and walnuts should never be confused! Unless pickers are closely watched, a good many fruit spurs will be broken off, especially if the fruit has a tendency to grow in clusters. This should be carefully watched, as it destroys the fruit buds for the coming year. The fruit should be picked a few days before ripe. Pickers earn $1.50 to $2 per day in a good crop, at 1 cent per pound.

The manner in which fruit is placed on the market, especially all delicate fruits, has as much to do with selling it as the quality of fruit itself. The demands of the market should always determine the method of packing. This can be learned by correspondence with reliable commission men, who would often obtain better prices for cherries and other fruit, if their advice were asked and followed. For the general market, there is probably no better package for the cherry than the 8-lb. climax grape basket, but for the finer classes of cherries and the retail trade (which should always be worked up for the finest cherries) a smaller package is more desirable. There are several packages which hold from six to twenty boxes or baskets, the whole package weighing not more than 40 lbs. when full, which are desirable. A package heavier than 40 lbs. will be roughly handled by transportation companies. In the small packages the fruit should be made very attractive. All stemless or bruised cherries should be thrown out, and the top layer of fruit faced in rows with the stems hidden. This work can be done rapidly by girls or women, who lay the cherries on the bottom of the box in rows, fruit side down, then fill the box, nail and turn it over, mark the faced side and put it in the crate. If baskets are used in the package instead of boxes, the top of each basket should be faced. The extra cost of facing the fruit pays in the ready sale which it brings.

I will recite a bit of our own experience of the present year: Black Tartarian and Napoleon Bigarreau cherries were packed in two styles of packages, the fruit being handsomely faced in both cases. A spring crate or case holding 6 boxes of cherries each containing 6 lbs. (36 lbs.), sold for $1.50 by one Boston firm and $1.75 by another, and $1.75 by a New York firm, or 4½ cts. per lb. Another case holding twenty 2-lb. baskets (40 lbs.), sold by the

Boston firm for $3.75 and $4, and by the New York firm for $4, or 9½ cts. per lb. Both packages cost the same. In another instance, Black Tartarians were shipped in 5-lb. baskets and sold for 30 cts., or 6 cts. per lb., while those shipped in 8-lb. baskets brought 65 cts. and 70 cts., or 8½ cts. per lb.

All these remarks apply to fruit sold in the general market; but there is a great demand for sweet cherries from the canning factories, for which the fruit, while carefully harvested, is less laboriously packed.

Profits.— The profits from the cherry industry depend mainly on the efforts of the grower in producing first-class fruit and in placing it on the market somewhat after the directions given in the previous topic. In 1888, an acre of cherry trees, 18 years old, including Black Tartarian, Black Eagle, Napoleon Bigarreau, Elton, Yellow Spanish and Downer's Late Red, netted $380, while an acre of rye netted $8.

The following sample figures are taken from sales from the orchard this season, trees 25 years old:

Five trees of Robert's Red Heart averaged 280 lbs. per tree; the fruit sold for 9 cts. per lb. bringing		$25 20
The expenses were:		
Picking	$2 80	
Packages	1 40	
Packing	1 25	
Express	2 80	
Commission	2 52	
		10 77
Net profit per tree		$14 43

One tree of Robert's Red Heart yielded 416 lbs., which sold to retail dealers at 10 cts. per lb. at the express office		$41 60
Expenses:		
Picking	$4 16	
Packages	1 56	
Picking	1 75	
		7 47
Net profit		$34 13

One acre of Windsors containing 70 trees 8 years old, yielded 84 lbs. per tree—5,880 lbs., which sold at 10 cts. per lb.		$588 00
Expenses:		
Picking	$58 80	
Assorting and packing	20 00	
Packages	30 00	
Express and commission	70 00	
Cultivation (plowed once and harrowed six times)	3 50	
Fertilizers (300 lbs. potash, 100 lbs. bone, 15 lbs. crimson clover seed)	4 25	
Interest on land at $1.50 per acre	9 00	
		195 55
Net profit		$382 45

All these figures refer to sales in the open market. There is a good demand for sweet cherries for canning factories. The canners generally prefer the "white cherries," those with a white juice and rather light-colored skin. The crop of sweet canning cherries in western New York appears to be growing smaller, and the California product has driven out much of the home-made goods. One of the best informed canners in the western part of the State writes as follows concerning the sweet cherry pack: "Up to six or seven years ago we handled from fifty to one hundred tons annually. The cherry crop appears to be growing smaller each year, and to be deteriorating very much in quality. Our output on cherries used to be composed largely of the white varieties, and we used to put up fine grades that were esteemed very highly in New York and the eastern markets. Some years ago California began to can cherries and subsequently put them on the eastern markets in competition with the finer grades of eastern cherries. The result was that the California product drove the eastern canned cherries almost entirely out of the market, except in some of the cheaper grades. The California cherry is much finer in appearance, is larger, freer from worms and imperfections, and also possesses a very fine flavor."

The canners tell us, in general, that when they can get good fruit, they have no trouble in making a saleable product. It is evident that good fruit cannot be obtained year by year, unless the trees are planted in such way that they can be well cared for. The price paid for sweet cherries for canning factories, runs from three to five cents per pound.

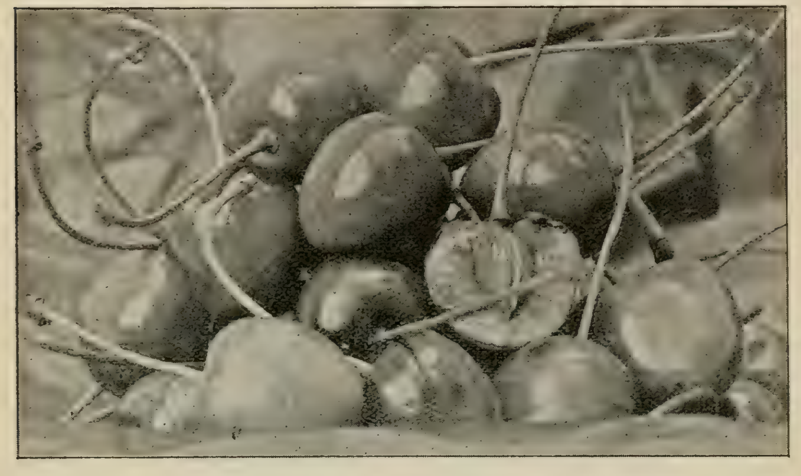
Varieties.—Among the most prominent Hearts are Belle d'Orleans, Knight's Early Black, Black Eagle, Black Tartarian, Kirtland's Mary, Coe's Transparent, Downer's Late Red, Elton and Governor Wood. The most prominent Bigarreaus are the Yellow Spanish, Mezel, Napoleon, Rockport, Tradescant's Black Heart (Elkhorn) and Windsor.

For general market purposes, the firm-fleshed varieties of a black or red color are preferable, as they ship better, do not show finger marks from handling, and are not so susceptible to the rot. From the Hearts, Knight's Early Black, the Black Tartarian, Black Eagle and Downer's Late Red might be added.

83.—Governor Wood.

Governor Wood is probably the cherry most common to western New York and is shown in Fig. 83. The tree is a vigorous grower and forms a regular, round head. The fruit is light red or light yellow with a red cheek, short-cordate, soft, sweet and good. Peduncle of medium length, inserted in a broad cavity; flesh nearly colorless. This variety is an excellent one for home use but cannot be recommended for market, because of its tender, light flesh, and its great susceptibility to rot. Ripens about the middle of June.

Elton.— The Elton is another cherry commonly set. Tree vigorous, upright, leaves with darkened footstalks. Fruit heart-pointed, distinct in shape, large, yellow, much overlaid with cherry red. Flesh firm, becoming soft, white, juicy when ripe, and luscious. Heavy, regular bearer, but not a desirable market variety, because of its light color, tender flesh and susceptibility to the rot. Fig. 84.

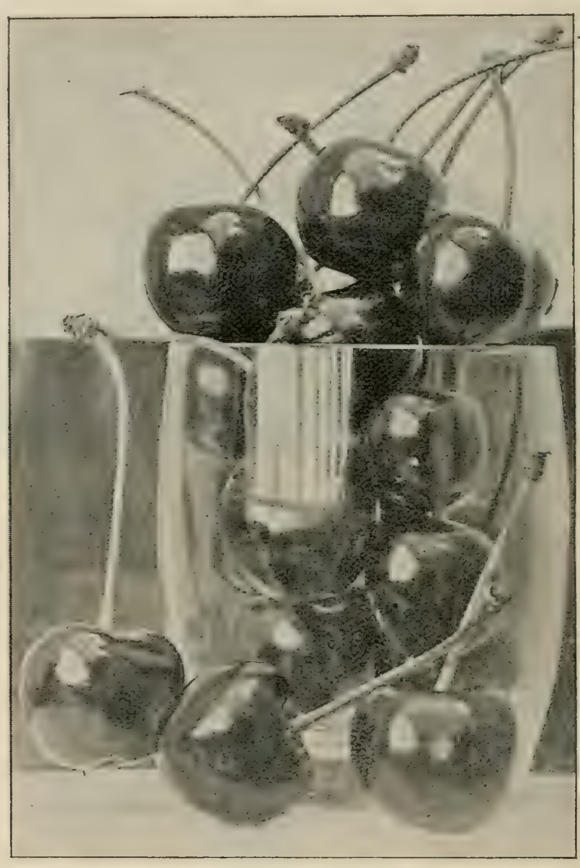


84.—Elton.

Black Tartarian.— Tree vigorous and rapid grower, erect when young, becoming spreading when older, the large limbs losing side branches giving the lower interior a bare appearance. Fruit attached by three, short-cordate, not pointed. Flesh dark purple, soft, but firmish; deep, dark red or black. Juice very sweet and abundant. Stone small. Peduncle 1½ inches long, set in a flatened, shallow cavity. Regular and heavy bearer, quality *excellent.* Ripe the middle of June. The Tartarian is the best black heart for market and family purposes. It does not rot as badly as the light hearts, and though not as firm as desirable, its high quality, regularity in bearing, and dark color recommend it strongly. Fig. 85.

Black Eagle.— Tree a rapid grower, erect with roundish head, top dense, large limbs not bare as in Tartarian. Fruit large, borne in pairs and threes, in thick clusters on the spurs, obtuse or pointed. Color same as Tartarian and slightly more acid. Flesh same color. Quality excellent. Moderate bearer. Does not rot as badly as the light hearts. One of the best dark hearts for market and family use. Ripe just after the Tartarian. Fig. 86.

Downer's Late Red.—Free, rapid grower, head upright and roundish. Fruit medium size, roundish, heart-shape. Skin of a delicate red, mottled with amber where shaded, very tender, melting, luscious. Fruit hangs for considerable time on tree. A heavy, regular bearer. Does not rot badly. Ripe about July 8th. A good, late, tender variety.



85.—Black Tartarian.

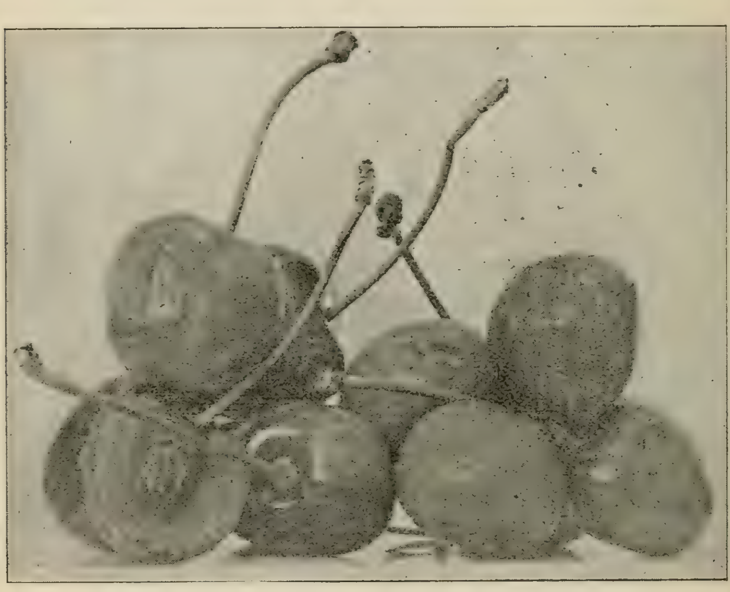
There are many other heart cherries that might be described, but it is the intention of this paper to give only the leading varieties; some may have been omitted and their descriptions can be found in the leading horticultural books. The same remarks may also be applied to the firm-fleshed kinds, only the leading varieties of which will be given.

Napoleon.— Tree medium size, erect with roundish head. Fruit borne generally in twos; very large, oblong-cordate; light lemon yellow with red cheek in the sun. Flesh *very* hard, brittle colorless, reddish at stone. Stem medium length, stout in a moderately deep, even cavity. Good. Excellent bearer. Ripe about June 20. Rots badly when ripe and splits if left too long. The Napoleon Bigarreau is probably the most desirable light colored cherry for market purposes. Its hard flesh and large size make it a good shipper and an attractive fruit when placed in small packages. Although it rots badly, if picked as soon as well colored and before ripe this difficulty will be largely obviated. It must be watched closely in humid weather and when the first signs of rotting appear, the crop must be picked or it will be lost. Fig. 87.

86.—Black Eagle.

Robert's Red Heart.—The following description applies to a variety of that name grown in eastern New York. The description given in Downing is not clear enough to positively establish its identity, but the history of the plantings seems to establish its name beyond a doubt. Tree erect, not spreading, roundish, vigorous grower, dense. Fruit short-cordate, as large and as fine as the Napoleon, in large clusters; bright dark red, with an under mottling. Peduncle long, set in a moderately deep, broad depression. Flesh pinkish; subacid. Juice nearly colorless. Handsome. Quality fair. Does not rot as badly as the Napoleon. *Very* heavy regular bearer. Ripens with the Napoleon. The fruit should be faced in fancy packages. One of the best firm-fleshed cherries. (Fig 88).

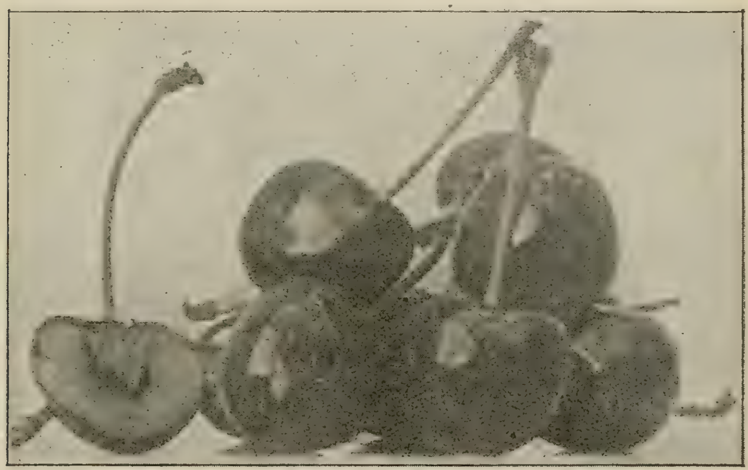
Mezel (*Bigarreau de Mezel*).—Tree a vigorous upright grower, leaves large, Fruit very large, obtuse, heart-shape, flattened on both sides, uneven. Skin dark red to black. Firm, but heart like, juicy meaty, very sweet and rich. Stem long, slender and tortuous. Handsome and excellent. Said to be a prolific bearer, though I have seen only a few trees in fruit. Ripe about June 20th.



87.—Napoleon.

Windsor.—Tree upright, vigorous and rapid grower, leaves large. Fruit large, roundish oblong, very firm, juicy, mottled red; flesh pinkish, sometimes streaked. Peduncle, medium length, stout, set in a slight broad depression. Quality good. Heavy bearer. Ripe about July 4th. Attacked freely by curculio. The most desirable late cherry either in the firm or tender-fleshed varieties. It hangs a long time and does not rot badly. Fig 89.

The Dukes are chiefly represented in New York by May Duke, Reine Hortense, and Belle de Choisy. The May Duke (Fig. 90) is a large very dark red cherry, short-cordate, soft, the flesh colored and sub-acid, of excellent quality. One of the best family cherries, but little grown for market because of its softness. A peculiarity of the May Duke is its habit of ripening unevenly. It is not infrequent that one branch or one part of the tree matures its fruit whilst the remainder of the crop is still green. Sometimes the two sides of the same fruit mature at different times. Reine Hortense is an oblong cordate, light yellow cherry overlaid with amber and splashes of light red. Flesh nearly white, very soft, sub-acid, of medium to good quality. Rots badly. Belle de Choisy is one of the best of dessert cherries, but is too unproductive and too soft for market purposes. It ripens just after the May Duke. Fruit roundish, the skin thin and amber with mottled red.



88.—Robert's Red Heart.

Varieties subject to rot.— In general, it may be said that the tender-fleshed varieties of cherries rot worse than those having firmer flesh among those which are the most susceptible to it are Governor Wood, Elton, Coe's Transparent, Belle d' Orleans, Belle Magnifique, Rockport Bigarreau, Cleveland Bigarreau, and Napoleon Bigarreau. Among those that are least susceptible are Black Tartarian, Black Eagle, Knight's Early Black, in the Hearts, and Robert's Red Heart, Mezel, Tradescant's Black Heart and Windsor in the firm-fleshed varieties.

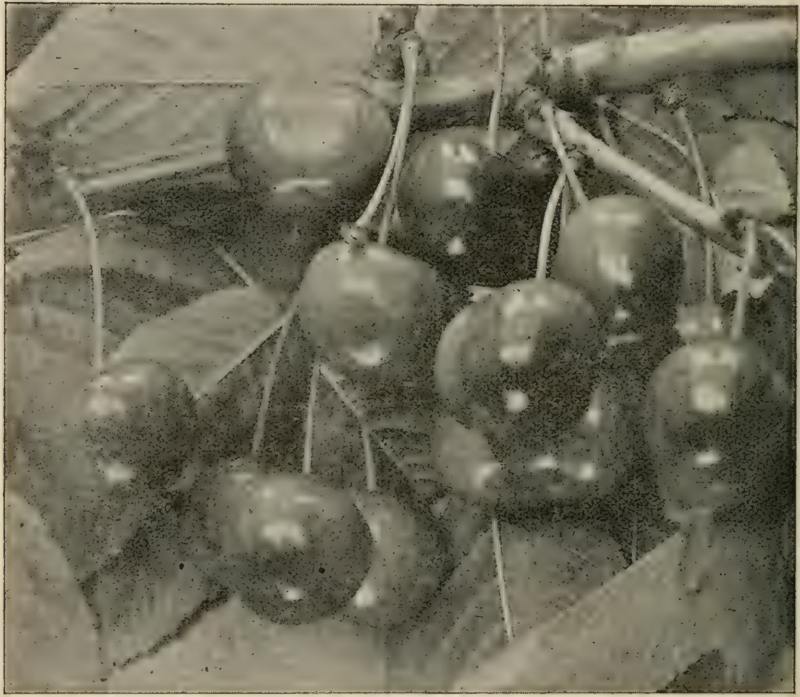
Family sorts.— For the family varieties the hearts are among the best on account of their tender, luscious flesh, though in point of excellence, some of the Bigarreaus are close competitors. I would recommend the following varieties for family use:

Hearts.— Black Tartarian, Governor Wood, Coe's Transparent, Belle d' Orleans, Downer's Late Red, Black Eagle, Knight's Early Black.

Bigarreaus.— Napoleon, Rockport, Robert's Red Heart, Yellow Spanish and Windsor.

Dukes.— May Duke, Belle de Choisy.

There are other varieties which are probably equally as good, but these can be recommended from long acquaintance.

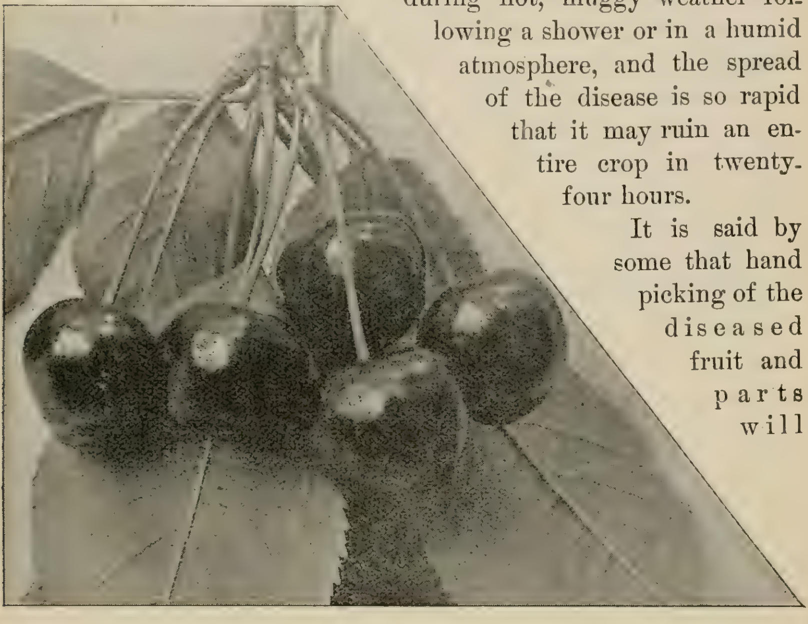


89.— Windsor.

Diseases.—The cherry is attacked by the same diseases that are common with plums, the principal one of importance affecting it being the fruit rot. The symptoms are familiar to all. The fruit turns brown and ash-colored tufts appear on it, which are the spore-bearing threads, and later the fruit falls, or becomes mummified and persists for a long time without decaying.

The twigs, leaves and flowers may also be attacked by the disease, causing the flowers to decay and die and the leaves to become discolored. The fungus passes the winter in the mummified fruits and begins to propagate in the spring, with the advent of warm weather. It attacks the fruit mainly just at the ripening period, principally during hot, muggy weather following a shower or in a humid atmosphere, and the spread of the disease is so rapid that it may ruin an entire crop in twenty-four hours.

It is said by some that hand picking of the diseased fruit and parts will prevent the spread of the disease, as it destroys the means by which the fungus passes the winter. This method is not practicable, because not more than a part of the fruit will be gathered, and because of the labor attached to it.



90.— May Duke.

It has been shown that spraying with Bordeaux mixture will control the difficulty and also prolong the ripening season.

The directions given by Craig * are that the trees should be carefully sprayed with Bordeaux mixture after the blossoms fall and that two or three applications should be made, the last being with ammoniacal copper carbonate a few days before picking. The application should probably be made every two weeks. I should substitute the ammoniacal carbonate of copper for the Bordeaux after May 1st, as traces of Bordeaux will remain on the trees for a month or more.

I am not convinced, however, that spraying is necessary to prevent the brown rot in New York State. The losses from this dis-

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*Bull. 23 Central Exp. Farm, Ontario.

ease which have come under my observation are invariably the result of letting the fruit hang on the trees till ripe and then the rot is very active; but cherries should be picked a few days before ripe, before they soften, and then the rot does not seriously affect them. An illustration of this point, which is a most important one, was brought to my notice the present season. The last week of June, in eastern New York, was very hot and close with showers every day or two. The cherries were then ripening and the conditions were favorable for the rot to spread. In one orchard from which several tons of cherries were shipped that week, there was not more than 150 pounds destroyed by the rot, while in another orchard a few miles distant at least 10 tons of the same varieties were ruined on the trees. In the first orchard the fruit was picked before it had ripened, and all that was fit was taken off *as soon as the trees dried off after a shower;* in the other orchard it was left till nearly ripe and one-half to two-thirds of the crop was lost before the fruit could be picked. So rapid is the work of this fungus at this period, that the owner of the orchard told me that he lost three tons of one variety in one night. It might be added that the orchard first mentioned was a much stronger one, as it was in cultivation, while the last had been in sod for years, and the general debility and neglect of the trees made them good subjects for the attacks of rot or any other disease.

The most serious insect pests are the black aphis and curculio. The aphis often attacks young trees and sometimes the bearing ones. They appear early in the season and multiply very fast. This aphis is found in great numbers on the young shoots and the under sides of leaves and on stems of the fruit, excreting a sticky substance which covers the pests; and the leaves curl up. It may appear as late as September but seldom in sufficient numbers to do injury. The aphis is a sucking insect and has to be treated with kerosene emulsion or whale oil soap, of which one or two thorough sprayings is generally sufficient to clear the trees. The spray must be applied *as soon as the aphis appears*, or the attacked leaves curl with the insect inside and it is impossible to reach them, and the full grown insect is very hard to kill. In such cases it is advised to pick the affected leaves and destroy them if possible and then spray so as to kill the remaining ones on the twigs and fruit.

The full treatment of the curculio is to be made the subject of a separate bulletin.

EPITOME.

Cherry growing is one of the neglected industries of western New York. There are practically no bearing orchards of sweet cherries, and very few of sour cherries.

The product is sold both in the open market and to canneries. In general, the factories afford the better market, although well grown and nicely packed fruits, particularly of the sweet kinds, find a ready sale in the general market.

Cherries like a loamy soil which is rich in mineral food. They should generally be given clean and frequent cultivation until the fruit is ripe, and after that the land may be put to rest with some cover crop. Stimulating or nitrogenous manures should be used cautiously.

Sour cherries should be planted eighteen to twenty feet apart each way, and sweet cherries about 10 feet farther.

Cherries are pruned after the manner of pruning plums and pears Sweet cherries should be pruned to three to five main arms, and not to a central leader. (Page 484.)

The curculio is the worst enemy to sweet cherries, and it is sometimes serious upon the sour kinds. Jarring the trees is the most reliable procedure.

The rot, due to fungus, is particularly bad upon the early and soft-fleshed sweet cherries. Spray for it twice before the fruit is half grown, with Bordeaux mixture. Plant varieties least susceptible to the disease (see pages 490–496). Be expeditious in handling the crop.

Cherries for the general market should be carefully hand-picked, with the stems on, and they should be neatly packed in small packages. Cherries for the general market, particularly the sweet kinds, should be handled with as much care as strawberries are. The smallest packages are the most profitable for the best cherries. (Page 486.)

The most deserving sour cherries for western New York are Montmorency, English Morello and Louis Phillippe. The last is best in quality, but apparently is least productive.

Of sweet cherries, the following are recommended for market: Windsor, Napoleon, Black Tartarian, Black Eagle, Mezel, Robert's Red Heart, Downer's Late Red. For home use, Black Tartarian, Governor Wood, Coe's Transparent, Belle d'Orleans, Downer's Late Red, Black Eagle, Knight's Early Black, Napoleon, Rockport, Robert's Red Heart, Yellow Spanish, Windsor, May Duke, Belle de Choisy.

L. H. BAILEY,
G. H. POWELL.

BULLETIN 99—August, 1895.

Cornell University Agricultural Experiment Station.

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BLACKBERRIES.

By L. H. Bailey.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in Western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
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92. On the Effect of Feeding Fat to Cows.
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94. Damping-Off.
95. Winter Muskmelons.
96. Forcing-House Miscellanies.
97. Entomogenous Fungi.

On account of the technical nature of Bulletin 97, *only a limited edition was printed for the use of Experiment Stations and Exchanges.*

98 Cherries.

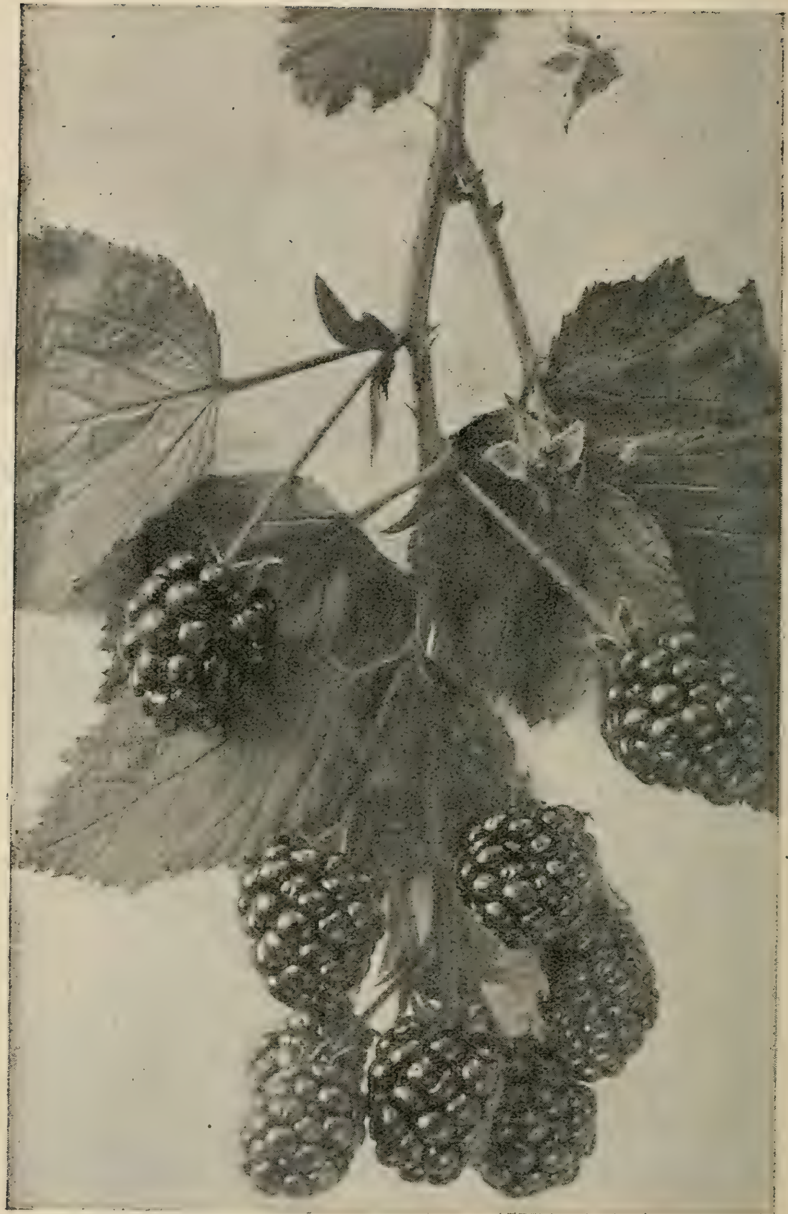
99. Blackberries.

CORNELL UNIVERSITY,
ITHACA, N. Y., *August* 20, 1895.

The Honorable Commissioner of Agriculture, Albany:

SIR.— This account of the blackberry is submitted for publication and distribution under Chapter 230, of the Laws of 1895.

L. H. BAILEY.



91.—Mersereau Blackberry, four-fifths natural size. Description on page 523.

Blackberries.

The blackberry is a neglected fruit in western New York. There are few persons who make any special attempt to grow it at its best upon a commercial scale. Yet, there is no bush fruit which is capable of yielding greater profit. It is the last of the small fruits, and when it is well grown it affords a luscious addition to the dessert of midsummer. Some of my readers will at once take issue with me respecting the lusciousness of the blackberry, and we may as well argue the subject to a finish whilst we are in the mood. In justification of my position, I shall say that those persons who do not like the garden blackberry have probably never eaten a ripe one. Those red and juiceless objects which one finds frying in the sun and patronized by flies in front of grocery stores are not the fruits about which I am writing. They might have been green berries or red berries, but they were never ripe blackberries. There is no fruit grown in this State which so soon deteriorates after picking, and none which is necessarily picked in such unfit condition. The blackberry is not ripe simply because it is black; it must be soft, and it must drop into the hand when the cluster is shaken. In this condition it is full of the sweetness and aroma of midsummer. It is our most delicious bush fruit. Of course, such berries as these never find their way to the market, and hence it comes that my reader who has never grown the fruit is still wincing in memory of the unbearable acid of the blackberry. Then there are those who declare that the tame berry is intolerably sourer than the wild one. It is true that it is more juicy when well grown, and this juice is very sour until the berry is soft to the core. But the flavor of the wild berry is usually quite as much a compound of pleasant memories of youthful associations and stimulating adventures, as it is of sweetness and flavor; and then, when one picks wild berries he always selects the ripest and the best, and these become the standard with which he compares the untimely fruits which he buys of the groceryman. I also held tenaciously to the opinion that the tame berry is inferior to the wild one until, a few years ago, I visited the wild patch in which grew those incomparable berries of my boyhood. But I found the berries scant and seedy, many of them inexcusably sour, and the briers were intolerable. I came back to my Agawams with relish, and they are to this day my ideal of summer fruits.

There seem to be three important difficulties in the raising of blackberries in this State: one is the slow price which sometimes prevails when there is a heavy competing crop of early peaches; another is the winter-killing of the plants; and the third is the effect of droughts. Respecting the first difficulty, I can only say that it is rarely serious if the fruit is well grown and attractively handled. Prices are generally good for worthy blackberries. With ourselves, they sell the best of any small fruit. The winter-killing is avoided by planting the hardiest varieties and by taking care not to keep the plants growing too late, and by heading the canes early so that the laterals become well matured. The effects of dry weather are often serious because the blackberry is largely water, and it ripens in the hottest part of the year. But the difficulty can be almost wholly avoided in New York by care in selecting land which does not quickly suffer from drought, and especially by early, frequent and timely cultivation.

Land.— The best blackberry land is a deep, mellow, clay loam; that is, a soil of which the body is clay,—and which, originally, might have been very hard,—but which contains considerable humus and crumbles rather than bakes in the furrow. Loose, gravelly lands are too deficient in water for the blackberry. It is very important to plow all hard lands deep and to fit them with much care before setting the plants, for, if the plants are to escape the effects of droughts, the roots must grow deep and there must be a liberal reservoir for water upon the foundation or hard-pan. Flat lands with high subsoil should always be tile-drained before blackberries are set upon them, else the bushes will generally suffer in winter, and the fruit is also more liable to injury from mid-summer droughts. It is generally best to set blackberries in the spring, and strong yearling plants are commonly used. One may use the suckers which spring up about blackberry bushes for setting, or he may grow them from root cuttings. The suckers are almost wholly used by commercial berry growers. These may sometimes be transplanted with success even after they have started to grow in spring.

Planting.—The plants are usually set in a furrow six or seven inches deep, and if the land is thin, stable manure may be scattered in the furrow. For all the ordinary large-growing varieties, eight feet between the rows is enough. This allows of easy cultivation. For myself I like them far enough apart to admit two horses in cultivating, as shown in the picture in our plantation, on the title-page. Two horses and a spring-tooth cultivator are the most efficient means which I have yet found of keeping a blackberry plantation in condition. In large plantations it is well to leave out a row occasionally, to allow of a roadway. In the row the plants are set from two to three feet apart. They will soon spread and fill the row. There are some growers who prefer to set the plants six or seven feet apart in the row in order to cultivate both ways, but this is profitable only where it is possible to give extra attention to tillage and pruning for the purpose of producing fine dessert fruit.

The year the plants are set potatoes or other crops may be grown between the rows, and the yield should be sufficient to pay for the use of the land. Some growers plant strawberries, not only between the rows but sometimes in the row between the plants; and it is possible, by good cultivation, to obtain two good crops of strawberries before the blackberries smother them.

Three or four canes may be allowed to grow the first year if the plants put out vigorously, and these will bear some fruit the following year. As soon as the canes have reached a height of two or three feet they should be headed back.

Training.—The subsequent training of the blackberry is simple, and it is essentially like that demanded by the raspberry. The operator must know, of course, that the shoots or canes which spring from the root one year will bear fruit the next year and that their usefulness is then ended. Every year, therefore, the canes which have borne fruit are cut out, and others are allowed to grow from the root to take their places. It is generally preferable to remove these canes as soon as the fruit is off, that is, in late August or early September; but the operation is usually delayed until a less busy season. They should always be removed before growth begins the following spring. These old canes are simply cut off close to the surface of the ground with long-handled shears, a spud or a cutting hook. Whilst the canes are bearing, others are growing from the root to take their place. A strong root may send up from ten to twenty shoots, but only a few of them should be allowed to remain How many shall be left must depend entirely upon the vigor of the plant, closeness of planting, strength of soil and like circumstances Usually five or six canes from each root are sufficient, and if very excellent fruit is desired the number may be reduced. The strongest canes should be left and the others pulled out when they are still only four or five inches high. It will be necessary to go over the patch four or five times early in the season to remove these superfluous shoots. It is true that many growers entirely neglect this thinning of the young shoots, but it is a question if better results would not always follow their removal.

92.—Early Harvest Blackberry patch in August. (Roland Morrill, Benton Harbor, Mich.)

These growing canes should be headed-in,— two to four inches of the tips cut off,— when they are from two and a half to three feet high. It will be necessary to go over the plantation three or four times for this purpose, as the different canes reach the desired height at different times. Laterals will now push out vigorously, but these are allowed to grow their full length. Early the following spring, these laterals are shortened. There is no rule respecting the proper length to leave these laterals. Sometimes they are injured by the winter and must be cut in short. And there is great difference in varieties in the way in which they bear their fruit; some kinds, like Wilson Early, bear the fruit close to the cane, whilst others, like Snyder and Early Harvest, should be cut longer. Some varieties are variable in their habit of bearing fruit, and on such kinds some growers prefer to delay the pruning of laterals until the blossoms appear. From twelve to twenty inches is the length at which the laterals are generally left. It must be remembered that these laterals are to bear most of the fruit; hence it is important that they make a good growth, become well matured, and that the grower familiarize himself with the habits of different varieties. It is generally important that the heading-in of the main cane be done early, so that the laterals may make an early and hard growth, and that they may start rather low down on the cane and thereby prevent the cane from tipping over with its load of fruit.

93.—Blackberries on trellis.

Blackberry bushes which are managed as I have outlined above will stand alone, without stakes or trellises. Such bushes are shown on the title page (Early Cluster) and a smaller-growing variety (Early Harvest) in Fig. 92. The bushes are sometimes kept from lopping by stretching a single wire along either side of the row, securing it to stakes which stand two or three feet high.

In some places, particularly along the Hudson, blackberries are trained on wires, after the manner of grapes. A blackberry trellis is shown in Fig. 93. The two-wire trellis is generally preferred. The young canes are headed-in just above the upper wire, and they are gathered in bunches in the hand and tied to the upper wire, where they will least interfere with the ripening fruit. These canes may remain on the wires all winter, or they may be laid down for protection. Early the following spring, they are tied securely to both wires. This makes, therefore, one summer tying for the young canes, and one spring tying for the bearing canes. Blackberries may also be tied to single stakes, although the practice is scarcely advisable because the fruit is apt to become to much massed in the foliage. Dewberries, however, which make a less rampant growth, are trained to stakes to great advantage, and when they are well grown, they are capable of becoming a valuable addition to the berry plantation, because they sell as blackberries and ripen a week or ten days earlier. Some growers in this State find the Lucretia dewberrry to be as profitable as the blackberry, and one or two correspondents even prefer it.*

Winter protection.— Protection in winter is rarely, if ever, necessary in western New York if the bushes are upon the proper land, if they have been judiciously cultivated and pruned, and if the hardier varieties are grown. Blackberries are extensively laid down in colder climates, however, and it may be well to relate the method here for the benefit of those who occupy bleak locations. Late in fall, the bushes are tipped over and covered. Three men are generally employed to perform this labor. One man goes ahead with a long-handled, round-pointed shovel and digs the earth away six inches deep from under the roots. The second man has a six-tined or four-tined fork which he thrusts against the plant a foot or so above the ground, and by pushing upon the fork and stamping against the roots with the foot, the plant is laid over in the direction from which the earth was removed. The third man now covers the plant with earth or marsh hay. Earth is generally used, and if the variety is a tender one, the whole bush is covered two or three inches deep. Hardy varieties may be simply held down by throwing a few shovelfuls of earth on the tops of the canes, thus allowing the snow to fill in amongst the canes. If the grower lives in a locality where he does not fear late spring frosts, the bushes should be raised early in the spring; but if frosts are feared they may be left under cover until corn-planting time. If the buds become large and are bleached white under cover, they will suffer when exposed to the atmosphere; and one must watch the bushes in spring and raise them before the buds become soft and white. This method of laying down blackberry plants costs less than $10 per acre, and the slight breaking of the roots is no disadvantage. Some growers dig the earth away on both sides of the row, and still others bend over the canes without any digging. Whatever method is employed, the operator must be careful not to crack or split the canes. The method can be varied with different varieties, for some bear stiffer canes than others.

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*A full account of the dewberries will be found in our Bulletin 34, which, however, is now out of print.

Cultivation.— No fruit profits more from careful tillage than the blackberry. This is largely because the fruit requires so much water, if it reaches its full capabilities, and the crop matures in the driest part of the season. The moisture of the soil can be well conserved only when tillage is begun very early in the spring. We generally plow our patches in the spring, and thereafter keep the land in fine shape by running over it every week with a cultivator. We generally prefer a spring-tooth cultivator, as shown on the title page. It is especially important to cultivate as soon after a rain as the soil is in condition, before it bakes. This tillage is continued until within a day or two of picking time. After the crop is harvested, one good cultivation is given to loosen up the ground which has been tramped down by the pickers and to fit it for winter. With us, this last cultivation occurs about the middle or last of August. In the drier summers west of New York, blackberry growers often mulch with freshly cut clover or manure close about the plants, leaving the center of the rows open for cultivation; but this is rarely, if ever, necessary in this State.

These frequent light cultivations are really cheaper than one or two, because the weeds never get a chance to grow and little hoeing is necessary. If a patch becomes foul with thistles and other weeds, the best procedure is to mow it off, plow it up thoroughly and crop it with corn for a season. Suckers will come up in the corn along the old rows, and the following year the plantation will be completely renewed.

Stable manure is the most popular fertilizer for blackberries. In general, it may be said that if the tillage is good, nitrogen will rarely be needed on good lands. Potash and phosphoric acid as advised for orchards (Bulletin 72) may, no doubt, be applied to advantage.

Yields and profits. — The year following the planting, there should be a sufficient yield to pay for the cost of the plantation to that time. The third year, the crop should be large, and from that time on, the yields should be nearly uniform, when the seasons are good. I do not know the limit to the profitable age of a blackberry plantation. It is certain that it should continue to bear heavily for twenty years, if it has good care, and I am told by careful growers that a patch will last even longer than this. As the plants are generally grown, however, they can not be expected to hold out this long, for the land becomes hard and foul, and the plants full of dead and diseased wood.

Blackberries are capable of yielding 200 bushels per acre, year by year, unless very unfavorable seasons intervene. This station once made an inquiry *amongst fifty growers in various parts of the country as to the average yield of blackberries. The lowest return was 40 bushels, and the highest over 300 bushels, and the average of the whole fifty was 98 bushels per acre. The prices in this State range from seven to fifteen cents a quart. J. M. Mersereau, of Cayuga, one of our best blackberry growers, recently said to me: "Let me choose the soil, and I will guarantee to clear over $200 per acre on blackberries." In our own experience at Ithaca, blackberries have sold the most readily of any of the bush fruits, at prices ranging from eight to fifteen cents a quart. Granville Cowing, Muncie, Indiana, a most successful grower of this fruit, makes me the following statements respecting the profits of it: "The blackberry is probably the most profitable of the small fruits. Owing to its firmness it can be kept much longer in good condition than the strawberry or raspberry, and often brings better prices. The best varieties are enormously productive, their cultivation comparatively easy, and a well kept plantation of them should last a life time." Whilst all these figures and statements are tempting, it must nevertheless be said that the blackberry, like all other fruits, yields the golden harvest only to those who work for it, and who think whilst they work.

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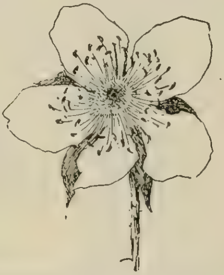
*"Raspberries and blackberries," by Fred W. Card, Bulletin 57. (Now out of print.)

Accidents and diseases.—The only serious accident which is known to injure the blackberry crop in this State is frost; and in most cases the injury is unavoidable, even though the grower has warning of its approach. In the six crops which we have grown in our patches here, only this year have we suffered from frost, and even this year, when the cold wave was unusually late and severe, only the lowest places suffered seriously. Drawings of blackberry flowers were made upon the spot, two or three days after the frost, and they are here reproduced, natural size. A normal, uninjured flower is shown in Fig. 94. Inside the five white petals or leaves, are seen the numerous sprawling stamens or so called male organs, each one bearing an enlargement or anther on the end, inside which the pollen is borne. In the center of the flower is the head or cluster of pistils or so-called female organs, each of which ripens into one of the little grains which go to make up the blackberry. The frost killed these organs, so that the center of the flower bore only a small black column of dead pistils. (Fig. 95). Now and then, one or more of these pistils in the head escaped and developed into a fruit-grain, so that the berry became a "nubbin." Fig. 96 shows the dead and aborted fruits at picking time. At the top of the picture are some fruits in which one or two grains or drupes are full grown, whilst all the rest of the berry did not develop.

94.—Blackberry flower. Full size.

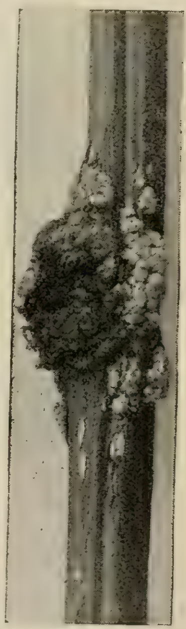


95.—Blackberry flower injured by frost.

There are four diseases of the blackberry which may be mentioned here,— the red rust or yellows, root-gall, anthracnose, and cane-knot. Except the last, these diseases will be more fully described in Bulletin 100, and they need not be discussed here. It may be said, however, that all these troubles can be kept at bay by keeping the patch tidy,—cutting out all suspicious canes and bushes, and by clean and careful culture. The yellows (*Cœoma nitens*) or red or orange rust of the leaves, is incurable, and the affected bush should be pulled out and burned as soon as discovered. With this treatment there is no difficulty in keeping a patch clean of the disorder. The same remarks apply to the root-gall. Anthracnose, or pitting of the canes, is less serious in blackberries than in black raspberries. It can no doubt be kept in check by careful spraying with Bordeaux mixture, as described in Bulletin 100; but I believe the most efficient treatment is to cut out and burn the old canes just as soon as the fruit is off, and to examine the bushes frequently for the disease and to cut out the diseased shoots. If a patch became very seriously involved, I should want to mow the bushes off close to the ground in fall or early spring, clean out the crowns and spray them, and

96.—Cut by frost.

start a wholly new top. This would sacrifice one year's crop, but the results would no doubt pay. The cane-knot (Fig. 97) is a disease of which the cause is unknown. In fact, I do not know that it has been described. The figure is an excellent picture of it. The knot reminds one strongly of the plum-knot, but there are numerous small whitish eruptions of the disease surrounding the parent knot. It may be of fungous origin, although we have not been able to discover constant deep-seated fungi on the knots which have been sent us. It probably attacks the growing shoots, although it is not apparent until the following year, when the grower, noticing that the leaves are yellow and the fruit not filling, examines the canes and finds these knots upon them. We have never had the disease in our own patches, and therefore can not give advice for its treatment, although I should advise the same sanitary treatment as I have for anthracnose. It is apparently not common, but it must be widespread, for I have had specimens from as far west as Wisconsin. Mr. D. F. Harris, Adams, New York, gives me this experience with the knot: "I came into possession of my patch three years ago. Variety said to be Snyder. The first year, a few canes were diseased; second year, about half of them were diseased; third year, nearly all diseased. I think that the disease begins to show in early spring on the old canes. I have never found it on the present year's canes. It progresses rapidly, as the fruit grows, and when the fruit is about two-thirds grown the leaves begin to wither, the cane dries up and the berries ripen. On very badly diseased canes, the berries wither and dry up."


97.—Cane-knot. Full size

Types and varieties.—What a silent evolution the blackberry has undergone! It is not yet fifty years since the first named blackberry, the Dorchester, was introduced to general notice. In 1857, the New Rochelle, or Lawton, was exhibited before the Massachusetts Horticultural Society, and thereupon blackberry culture began to attract wide attention in the country. The Lawton held undisputed sway until it was superseded by the Kittatinny some ten or fifteen years later. The Kittatinny, in turn, gave way to the

Snyder in about ten or fifteen years, and this latter variety is now the leading commercial blackberry. In the meantime, however, a host of varieties had appeared, very many of them wildings or chance bushes found in fence rows and copses, but so quietly have they come in that no one has been sufficiently attracted by them to inquire minutely into their genesis or to attempt to classify them into botanical groups. Consequently, the botanical features of the cultivated blackberries are little understood, which indicates that the crop has received little scientific attention. The garden blackberries, as I understand them, fall into five categories:

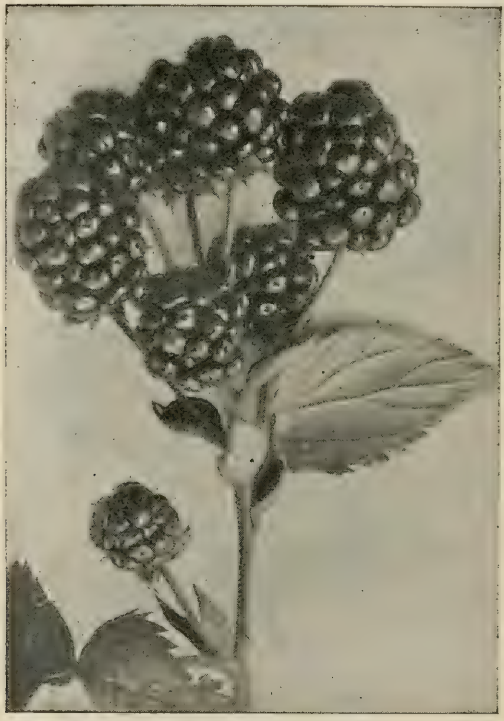
98.—The tall, wild blackberry. Life size.

I. *Long-cluster blackberries* (*Rubus villosus*). Best represented by Taylor (Fig. 104), although Early Cluster (Fig. 103), and Ancient Briton are evidently to be referred to the group. It represents the commonest large-fruited form of the wild blackberry, which grows in moist shady copses or in woods. This wild berry is seen natural size in Fig. 98. This form is distinguished by a long, loose, open and leafless cluster of long-stemmed, elongated fruits, very tall growth, leaflets mostly long-stalked, rather thin, evenly and rather finely serrate, and taper-pointed. Typical fruits

99.—Cluster of Early Harvest.

of this class are cylindrical-thimble-shaped, the drupelets rather small and uniform.

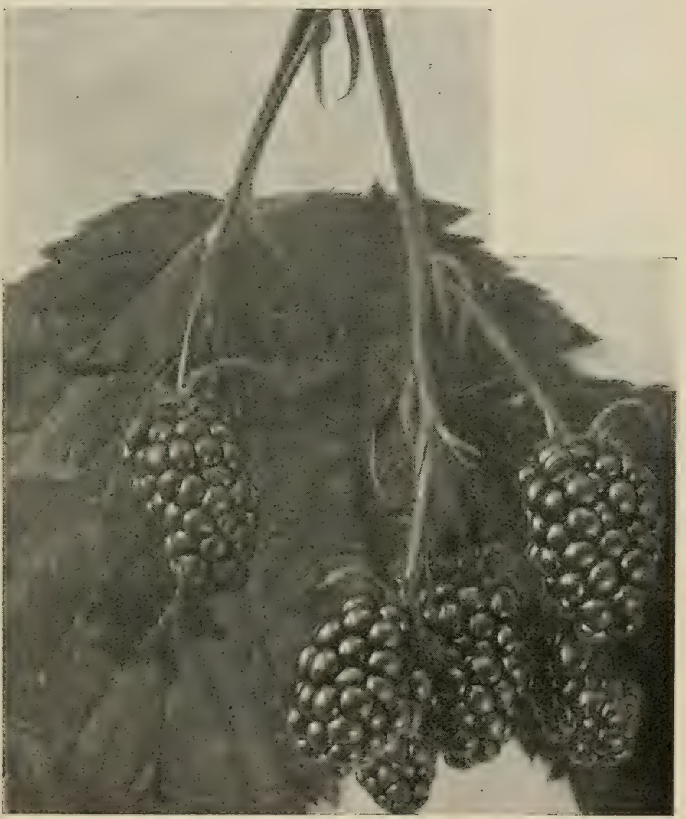
II. *Short-cluster blackberries* (*Rubus villosus*, var. *sativus*, Bailey, Amer. Gard. 1890, 719).—This is the commonest form of cultivated blackberry, and includes such varieties as New Rochelle, Kittatinny (Fig. 101), Snyder (Fig. 100), Agawam (Fig. 102), Erie, Minnewaski, and Mersereau (Fig. 91). A typical cluster of this group is shown in Fig. 91. It is comparatively few-fruited, leafy, the stems oblique rather than spreading, the topmost fruits more or less aggregated. The fruits are rounder than in group I., the drupelets larger and mostly softer and less uniform in arrangement. The leaflets are broader, more abruptly pointed, and generally very coarsely and unevenly serrate or even jagged. In its wild form, this blackberry is common in open and dryish places, where it forms a bush generally only two or three feet high, bearing a short cluster of small roundish mostly loose-grained fruits. The varieties of this



100.—Snyder. Full size.

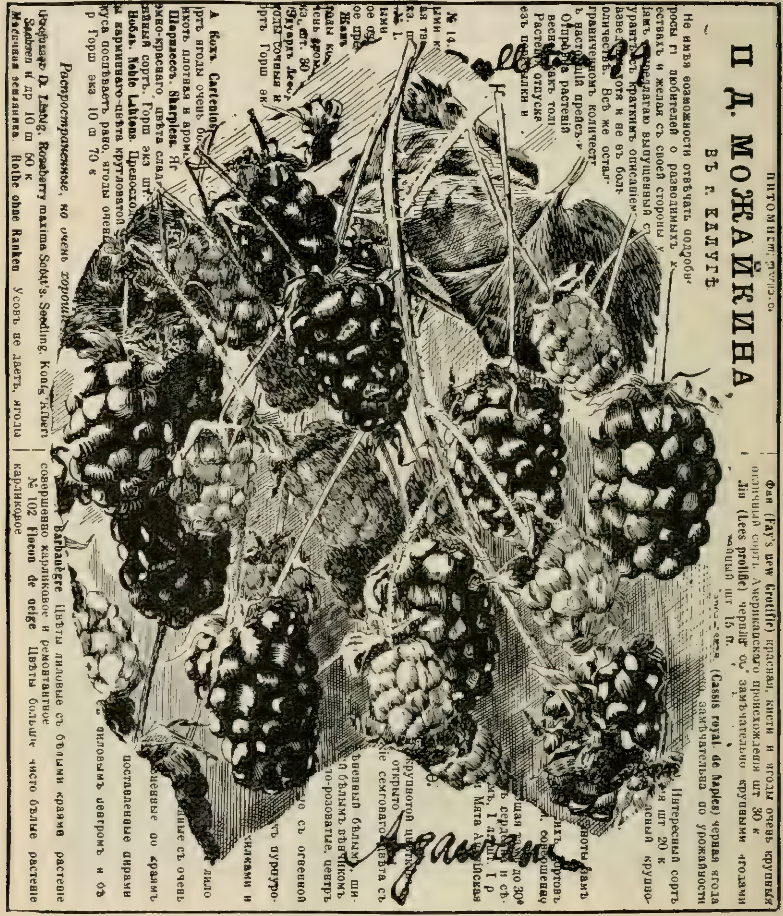
type have a strong tendency to produce a few later fruits on the tips of the new growth. These late fruits often ripen as late as the first week in September.

III. *Leafy-cluster blackberries* (*Rubus villosus*, var. *frondosus*, Torr).—These are dwarf, strict bushes, generally growing on dryish soils, bearing the flowers in short leafy clusters (Fig. 99), the leaflets small and firm, more or less wrinkled, light-colored, persisting long in the fall, smooth or nearly so when full grown, narrow, coarsely-toothed. Fruit early, roundish, medium to small, the grains large and rather loose. This is a very leafy plant, and is no doubt a distinct species from the common blackberry. In cultivation, it is known in the Early Harvest and Brunton's Early.



101.—Kittatinny. Natural size.

IV. *Loose-cluster blackberries* (*Rubus villosus* × *R. Canadensis*).—A mongrel class, comprising Wilson Early, Wilson Junior, Sterling Thornless, Rathbun, and probably Thompson's Early Mammoth. The class is characterized by a low and often diffuse



102.—Agawam. Natural size.

growth, broad, jagged and notched leaves, mostly loose-grained, roundish or roundish-oblong fruits, which are sometime very large, and particularly by the few flowers scattered on long stems towards the end of the canes. Sometimes, as in the Rathbun and others, the canes have a distinct tendency to root at the tip, after the manner of the dewberry. These blackberries are hybrids of the common blackberry and the dewberry. All of the cultivated sorts, so far as I know are natural hybrids, or, like the Wilson Junior and Sterling, offsprings of a natural hybrid (Wilson Early). Natural hybrids are common along roadsides in central New York.

V. *Sand blackberry* (*Rubus cuneifolius*).—The Tree Blackberry of Childs, and the Topsy, are forms of this viciously thorny species, which grows wild in sandy lands from southern New York southwards. It is a low plant (2 to 3 feet high), the cultivated forms suggesting the Early Harvest type. In wild specimens the under surfaces of the thickish, wedge-obovate leaflets are white, with a thick hairy covering, but much of this disappears under cultivation. The fruit is borne in loose, leafy clusters, and is globular, loose-grained, very black, often sweet and of excellent quality. I do not know of any cultivated forms which are valuable.

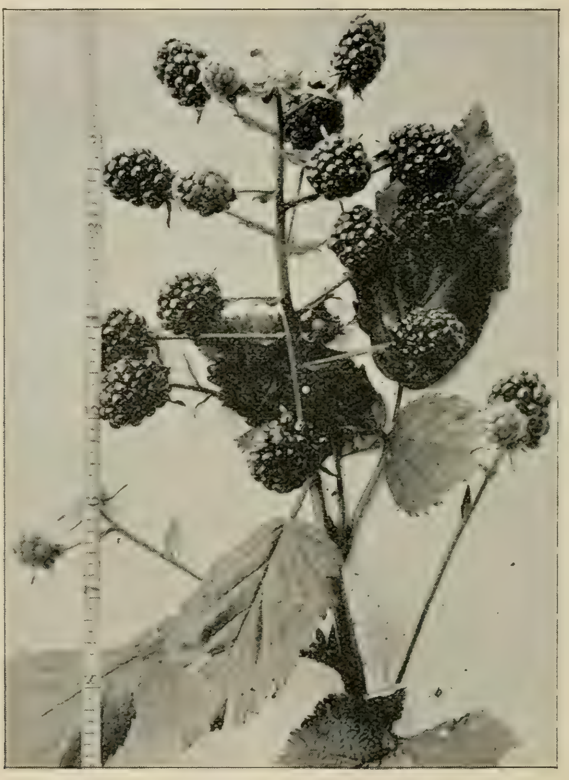
The varieties of blackberries which are much esteemed in New York are few. I append brief descriptions of a few of them. The various recent kinds are not yet sufficiently tested to warrant a description of them in a paper of character.

Snyder (Fig. 100).—By far the most popular blackberry in this State. Early, hardy, very productive. Berries of medium size, nearly globular, of fair quality when well ripened. The one serious defect of the Snyder is the tendency of the fruit to turn red when placed upon the market, particularly if it is picked before fully ripe. This difficulty may be obviated somewhat by keeping the berries covered after they are picked, to exclude the light. This, in fact, should be done with all blackberries. Found wild over forty years ago in northern Indiana.

Minnewaski.—Much like the Snyder, and popular along the Hudson. Comes in just after Snyder and averages larger, but, under all conditions, it does not seem to be so uniformly productive and it is not so hardy. As commonly consumed, it is very sour, but its quality is excellent when it is allowed to ripen on the bush.

Kittatinny (Fig. 101).—One of the oldest and best known blackberries, of most excellent quality and the fruit long and large, but now little grown in New York because of its tenderness and susceptibility to red rust. In somewhat protected localities and on well drained soils, it generally passes the winter safely if cultivated judiciously, but it is not generally reliable in this State.

Ancient Briton.—One of the most popular varieties in Wisconsin, where it first became known, and one which we have grown for a number of years and which we find to be very valuable. It is one of the hardiest varieties, very productive, about the season of Snyder or a trifle later, the berries large, long, of first-rate quality. The bush is a steady grower, and if headed back early in the season it stands very stocky and erect. There is much conflict of opinion in New York respecting this variety, and I suspect that much of the stock is spurious. It was "brought to this country from Great Britain about forty years ago by a Mr. Guy, for the late Robert Hassell, of Alderly, Wisconsin, who gave it the name." *



103.—Early Cluster. Half size.

Agawam (Fig. 102).—A large berry of most excellent quality, generally ripening with Ancient Briton. Fruit oblong, in rather heavy clusters. Productive and hardy with us, and we consider it one of the best, particularly in quality.

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*A. Clark Tuttle, Amer. Gardening, xiv. 305.

Erie.— Tender in western New York; therefore, little known here.

Early Cluster (Fig. 103).— This has been the most uniformly productive of any variety which we have grown, and we have fruited about 200 plants of it for five years. It is as hardy as Snyder, and is fully a week earlier. A moderate, erect grower, with medium-sized fruits in long and open clusters. There seems to be much misconception respecting this variety. Some growers report it to be tender and worthless. We procured our stock of Ellwanger & Barry, and I have sent the fruit to John S. Collins, the introducer, who pronounces it to be "Early Cluster, without doubt." Original plant found about 1872 amongst Missouri Mammoth, on farm of Charles W. Starn, New Jersey. Introduced in 1883.

Taylor (Fig. 104).—Very hardy, as productive as Snyder, the long, thimble like fruit borne in immense clusters and of the very best quality. It is about two weeks later than Snyder, ripening with the old Lawton, and generally closes the blackberry season in this State. One of the very best.

Mersereau (Fig. 91, page 504).—A variety strongly resembling the Snyder, and derived from it, but not yet generally disseminated. Its advantages over Snyder are its larger size, less tendency to turn red after being picked, better quality, and a stronger habit of perfecting some of its fruits as late as the first of September. Its ordinary season is that of the Snyder. This variety originated with J. M. Mersereau, Cayuga, New York, for whom I am glad to name it.* Some three or four years ago, Mr. Mersereau noticed an extra good bush amongst his Snyders, and began to propagate from it. He is now gradually changing his whole plantation over to this new variety, which differs from Snyders, in addition to the points mentioned above, by the much lighter cast of its foliage. It is one of the most promising varieties which I know.

Early Harvest and *Wilson Early* are little grown in this State. It is commonly supposed that both of them are very tender, but Early Harvest stands our winters fairly well. Wilson, however,

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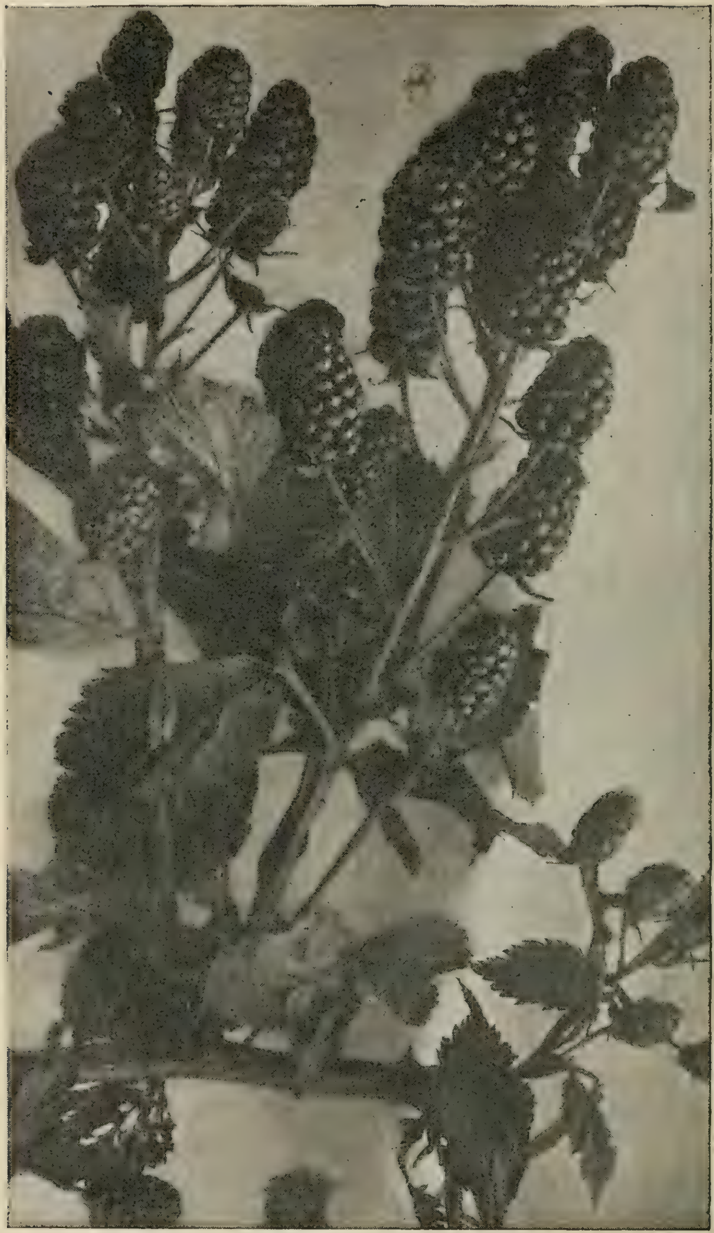
*It was described, briefly, as "Mersereau's Seedling" in Bull. 81, new series. New York State Experiment Station (Geneva), December, 1894.



101.—Taylor. Three-fourths life size.

needs protection; and both varieties are easily laid down, because of their dwarf habit. Their particular merit is earliness, although Wilson is also very large. These varieties are exclusively grown by Roland Morrill, Benton Harbor, Michigan, who is president of the Michigan Horticultural Society, and one of the most successful fruit growers in the state (see Fig. 92.) Wilson Early is an old variety, having been planted extensively in New Jersey thirty years ago. The Wilson Junior, which is practically indistinguishable from it, was grown from seeds of it, supposed to have been crossed with Dorchester, which were selected in 1875, by William Parry.*

BRIEF.

Blackberries deserve greater attention from western New York fruit-growers.

The tame berries are, as a rule, superior to the wild ones if they are allowed to hang on the bushes until fully ripe.

No bush fruit deteriorates so rapidly after being picked.

Winter-killing of the plants, which is a serious menace to blackberry growing, is avoided by selecting hardy varieties, planting upon thoroughly well drained land, and stopping cultivation as soon as the fruit is off. Or the bushes may be laid down, as described on pages 510, 511.

Drought often cuts the crop short. This difficulty is to be avoided by selecting lands which are not droughty, by thin planting, and by beginning tillage early in the spring and continuing it at frequent intervals until the fruit is nearly ripe. The method of cultivation which this bulletin advises is found on pages 511, 512.

Blackberries are generally planted in the spring. Eight or nine feet should be allowed between the rows, and two to three feet between the plants in the row. Potatoes or other crops may be grown between the rows the first year.

Training and pruning are described on pages 507 to 510.

Blackberries yield all the way from nothing to 300 bushels per acre. The variations in the yields measure the alertness and intelligence of the grower. One hundred bushels to the acre may be considered to be a good average yield. A fair crop should be obtained a year after the plants are set, and a good one the second year. A blackberry plantation may continue to be profitable for twenty years or more.

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*William Parry, "Fifty Years among Blackberries," 4.

The way in which spring frost injures blackberries is shown by pictures 94, 95, and 96; and an account of it may be found on pages 513, 514.

There are various diseases which thrive in half-kept blackberry plantations, but which may be headed off if the owner is alert and diligent. See pages 514 and 515.

No one can tell the intending blackberry grower what varieties he ought to plant. The grower must find that out for himself. But if he lives in western New York, he will be likely to succeed with Snyder, Taylor, Early Cluster, Ancient Briton, Agawam and Minnewaski; and he should try all others. Very early varieties are Early Harvest, Wilson Early, Wilson Junior, and Early Cluster; Snyder is medium early; Taylor is very late.

One who is curious to know about the botanical features of our cultivated blackberries, may read pages 517–525.

L. H. BAILEY.

BULLETIN 100—September, 1895.

Cornell University—Agricultural Experiment Station.
HORTICULTURAL DIVISION.

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Evaporated Raspberries in Western New York.

By L. H. Bailey.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in Western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. On the Effect of Feeding Fat to Cows.
93. The Cigar-Case Bearer.
94. Damping Off.
95. Winter Muskmelons.
96. Forcing-House Miscellanies.
97. Entomogenous Fungi.

On account of the technical nature of this Bulletin, only a small edition is printed for the use of Experiment Stations and Exchanges.

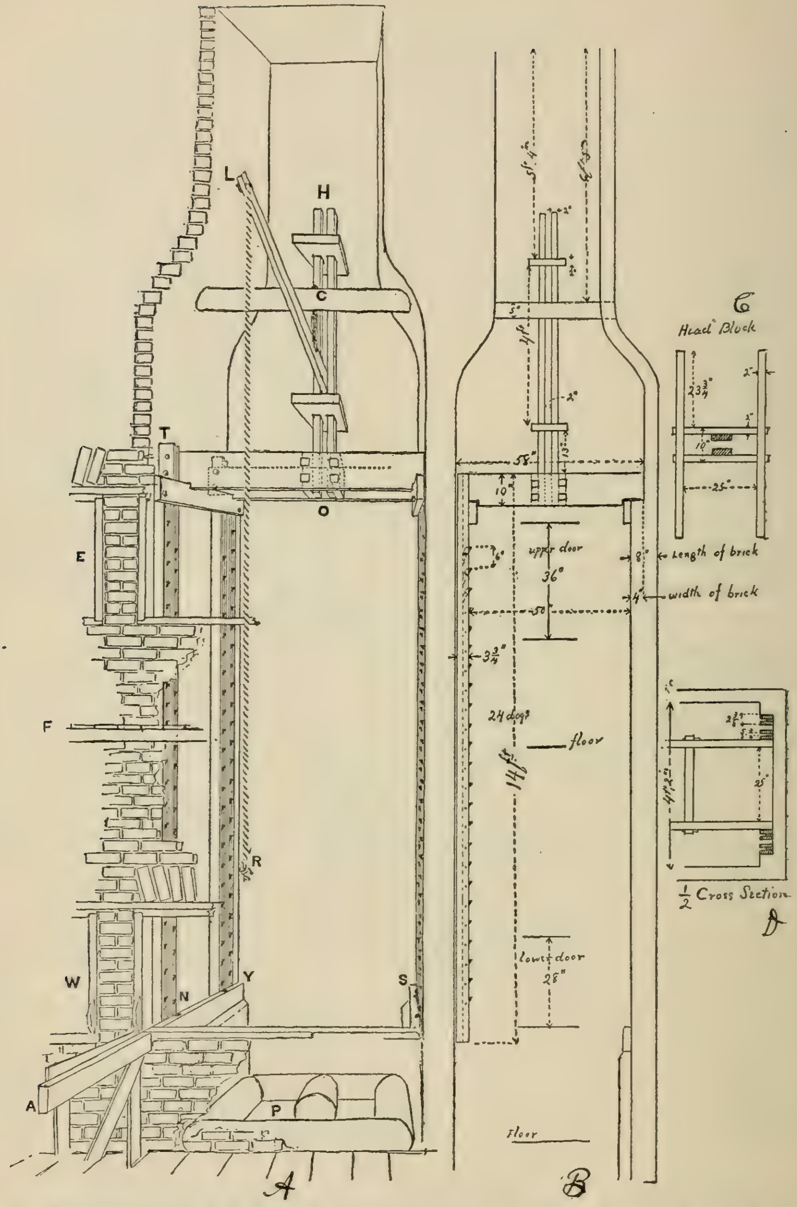
98. Cherries.
99. Blackberries.
100. Evaporated Raspberries in Western New York.

Cornell University,
Ithaca, N. Y., *Aug.* 31, 1895.

The Honorable Commissioner of Agriculture, Albany:

Sir.—This paper, designed to be published under the auspices of the Nixon bill (chapter 230, Laws of 1895) deals with the second most important product of evaporators in western New York. The first place must be given to evaporated apples. Besides these articles, the following products are evaporated in the east: peaches, pears, quinces, plums, cherries, currants, potatoes, peas, corn, pumpkins. There is no important account of the evaporating industry known to me, and I have therefore taken some pains to describe the mechanical part of the business, an account which I hope later to be able to extend. I am so fully convinced of the value of the evaporator to all persons who grow fruit, that I have extended this narrative somewhat beyond the requirements of the subject immediately in hand.

L. H. BAILEY.



105.—Evaporator stack of W. H. Bush, with Culver-Cassidy fittings. Diagram A looks at the back (O Y S) and inside of the front (T E W Y) of the stack. B shows front-view section. C is the head-block (L H C O in diagram A). D is cross-section of head-block. Fully described on pages 536 to 541.

Evaporated Raspberries.

I. THE EVAPORATOR.

WESTERN New York leads the world in the production of dried raspberries. Something like 1,500 tons of the evaporated product are marketed each year. Of this about 1,000 tons are produced in Wayne county, in which the towns of Williamson and Sodus, which produce nearly or quite half of the amount, are the most important centers. Marion, in Wayne county, is also a heavy producer of dried berries. Outside of Wayne county, the region tributary to Dundee, Yates county, is the most important center of the dried raspberry industry. The product sold at Dundee is probably upwards of 150 tons each year. Many berries are also dried south and east of Dundee, in Schuyler county, round about Watkins. In Niagara county the industry has become established at Somerset, where about 20 tons are produced each year. There are also many persons who dry raspberries in other parts of the fruit regions of western New York, and the industry is gradually enlarging as people come to learn that it affords a means of making the grower independent of the open market.

Yet the visitor might inquire in vain for dried raspberries in many of the stores in this western New York country. In other words, the product is not largely consumed in this State. It is used mostly west and northwest of Chicago. Probably four-fifths of the product is consumed in lumber and mining camps, and on the plains, where fresh fruit is scarce. None of it, so far as I know, is exported, and there is very little, if any, commercial dried product in Europe. C. H. Perkins & Co., Newark, N. Y., "tried the experiment of exporting some of these goods to France several years ago, but shipped only two or three cases of them. The goods are still on hand in France, with no disposition to take them at any price." Raspberries are dried to an important extent in southern Illinois and in Michigan, and lately also in Arkansas. These dried raspberries have as much merit in cookery as the fresh berries, and they are used in the same manner in sauces and pies.

Wayne county is the home of commercial fruit evaporation. In the apple growing communities nearly every farm has an evaporator of one kind or another. It is said that there are 2,200* evaporators in the county, and this estimate is probably none too high. All this industry is the product of the last twenty-five years. The beginning of the industry seems to have been the introduction of a little machine from Ohio (probably the D. Lippy fruit drier.—*Rept. Com. Patents*, 1865, *iii*, 378), by A. D. Shepley and George Edwards in 1867. The right to use this evaporator was purchased by Mason L. Rogers, near Williamson, and the following year, 1868, he planted five acres of black raspberries, with the expectation of evaporating the fruit — or drying it, as the operation was then called — and this began the evaporated raspberry industry. Mr. Rogers made some improvements on the machine, and about 1875 H. Topping, of Marion, took up its manufacture, making alterations from time to time. The direct descendant of this old machine is the Topping portable evaporator of the present day (Fig. 106), which is deservedly popular with beginners and for family use. The original machine, as sold by Shepley and Edwards, was made in two sizes, the smaller capable of drying three bushels of apples in eight to ten hours, and the larger with a capacity of five bushels! This small beginning seems incredible when one compares it with the great establishments of this time, in which scores of hands are employed and thousands of bushels are consumed annually.

The beginning of the modern industry, however, and the introduction of the word "evaporated" to designate the product, dates from 1870, when Charles Alden, of Newburgh, New York, patented his tower evaporator. The decade from 1870 to 1880 was prolific in the invention of capacious evaporators and accessories, some of which determined the course of the evaporating industry. The Williams evaporator, invented by John Williams, South Haven, Michigan, was patented in 1873. This was soon followed by the Culver machine, which was patented after the death of its inventor (Stephen Culver, Newark, N. Y.,) in 1882, by his administrator, Harlan P. Van Dusen, also of Newark. (Filed September 20, 1880; patented October 3, 1882.—See *U. S. Gazette of Patents*, xxii. 1171.) As early as 1876, Mason L. Rogers "built and equipped a Culver evaporator," as his son writes me. John W. Cassidy patented his device for lifting trays in 1876. Cassidy was a resident of Newark, New York, but moved to Petaluma, California, where he resided when he took out his patents. His device, combined with Culver's, is the leading lifting arrangement now in use in western New York. Cassidy took out another patent in 1880 for a device to dry fruit by exposing it alternately to a vacuum or partial vacuum, and an inrush of dehydrated air, but this system is probably unknown in this State. It now needed only the advent of a bleaching device and improved machines for paring and ringing the fruit, to establish the evaporating business upon an enduring basis; but as these devices are not used in the making of evaporated raspberries, they need not be further discussed in this paper.

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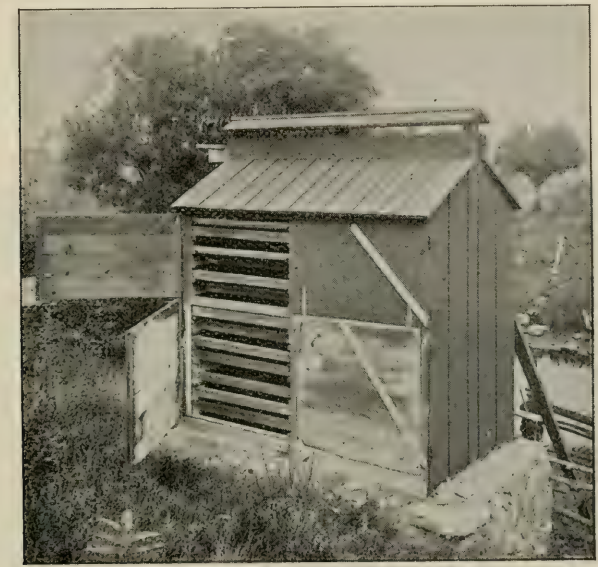
* Statement of Charles Mills, *Country Gentleman*, April 18, 1895, p. 308.



106.—Topping Portable Evaporator.

I. *The kiln drier.*

The evaporators which are used in western New York may be arranged in five categories,—the kilns, horizontal evaporators, towers, steam tray-evaporators, and air-blast-evaporators. The kiln is nothing more than a slatted floor, underneath which hot air or smoke pipes or steam pipes are conducted. The slats are hard wood, sawed about seven-eighths inch wide on top and a half-inch wide on the bottom, and they are laid so that a crack one-fourth inch wide is left on the floor. As the crack is wider below, it does not clog and fill up. The kiln is used for curing hops, for drying the skins and cores of apples, and occasionally for drying raspberries and even for the making of "white stock," that is, the commercial grade of sliced evaporated apples. Fig. 107 is a kiln (Mrs. S. C. Perrigo, Somerset) in which raspberries are drying. The smokestack from the furnace runs through the room, and beneath the floor, but not shown in the picture, is one circuit of a stove pipe carrying hot air. In this particular floor the slats are close enough together to allow raspberries to be spread upon it; but floors which are built for hops or apples are generally covered with muslin when raspberries are to be dried. Kilns are generally less efficient in the production of a

107. — Kiln evaporator, with raspberries a-drying.

first quality of dried fruit than the other styles of evaporators, because the fruit is not so completely under the control of the operator. The fruit must be shovelled over from time to time to insure a uniform product. This handling is itself a menace to good fruit, and when there is any quantity of fruit on the floor it can not all be dried equally. That which is dried enough is generally obliged to wait until the least dried portion is perfected. Yet there are instances in which the operator exercises sufficient care to turn out a product which is indistinguishable from the tower-dried fruit. The particular merit of the kiln evaporator is its cheapness.

2. *The horizontal drier.*

The horizontal evaporators in which the pans or trays of fruit are moved horizontally or obliquely across the heating surface, are little used in western New York, and are therefore not discussed in this paper.

3. *The tower drier.*

The tower or stack evaporators, in various forms, far out-number other appliances in this State. The stack is a chimney like structure, of wood or brick, resting in the basement of the building and extending up through the building and projecting above the roof. A coal or wood furnace — preferably the former — is placed in its base, and air which is drawn in from the basement passes over the heated surfaces and ascends through the shaft, drying the fruit as it rises and carrying the vapors into the atmosphere. The fruit is placed in the stack on the first floor, that is, the floor above the basement. It is spread on trays, and as new trays are put in, those which were first inserted are elevated in the tower. The trays finally reach the second story, by which time the fruit should be finished, and the trays are removed and emptied and taken back to the first floor, to be used again. This, in brief, is the principle upon which the tower evaporators work, but there are endless variations in the details, to some of which we must now direct our attention.

The first stacks were built of wood. In 1881, L. R. Rogers, son of Mason L. Rogers, to whom I have already introduced the reader, built stacks of brick from the basement to the top of the drying chamber in the second story. This was on the old homestead near Williamson, and the building erected the year previous and now standing is shown in Fig. 108. The tops of the stacks are dimly shown projecting from the roof of the main building at the rear. A year or two after this, W. H. Bush, of Marion, built brick stacks from cellar to cupola, and such stacks are now frequently seen. The advantages of the brick stacks are durability and safety from fire. The greatest danger of fire is inside the stack, and the wooden fittings and trays of these brick towers could burn out without setting fire to the building. It is the common practice to build the stack inside the building, chiefly because it is a prevailing opinion that the wind interferes with the draft if the stack is built against the building and exposed on three sides. This opinion is held in respect to brick stacks, in particular, for it is thought that the air will draw through the brick walls, and that they will also become damp in stormy weather, if exposed. This notion appears to be unfounded, however, for W. H. Bush, of whom I have spoken, has recently erected a most successful establishment at his new home at Walworth, with three outside brick stacks, with four-inch walls. Mr. Bush has had much experience in the evaporating business, and as I consider his new outfit to be a model in its way, I shall have much to say about it later on. (See Figs. 105, 109, 110, 111, 112).

108.—Evaporator on the Rogers homestead at Williamson.

The interior of one of these stacks must now be seen. We will first turn our attention to the basement or foundation of Mr. Bush's three stacks (Fig. 111). It will be seen that there are three furnaces, one under each tower or stack. There are two long openings into each, to admit the air. The smoke pipes from these furnaces run off across the cellar and discharge into the chimney, which is plainly shown in Fig. 109. Going up stairs, we find the aspect of the stack on the first floor to be that shown in Fig. 112. This is the door through which the trays are placed into the stack. If we raise this door, F W, and look down to the furnace, we see a coil of stove-pipe, P in Fig. 105, over which the air passes on its way up the tower. But before we proceed to an examination of the inside of this tower, let us look more carefully to the arrangements in Fig. 112. The tray is laid upon the frames A A (one of these is shown at A in Fig. 105), the little door, F, is raised, and the tray is shoved into the stack. V is a hand-hole, inside of which a thermometer may be hung. W is a large door, fastened by a button at X, to be used whenever the stack is cleaned or repaired. The opening is large enough to admit a man.

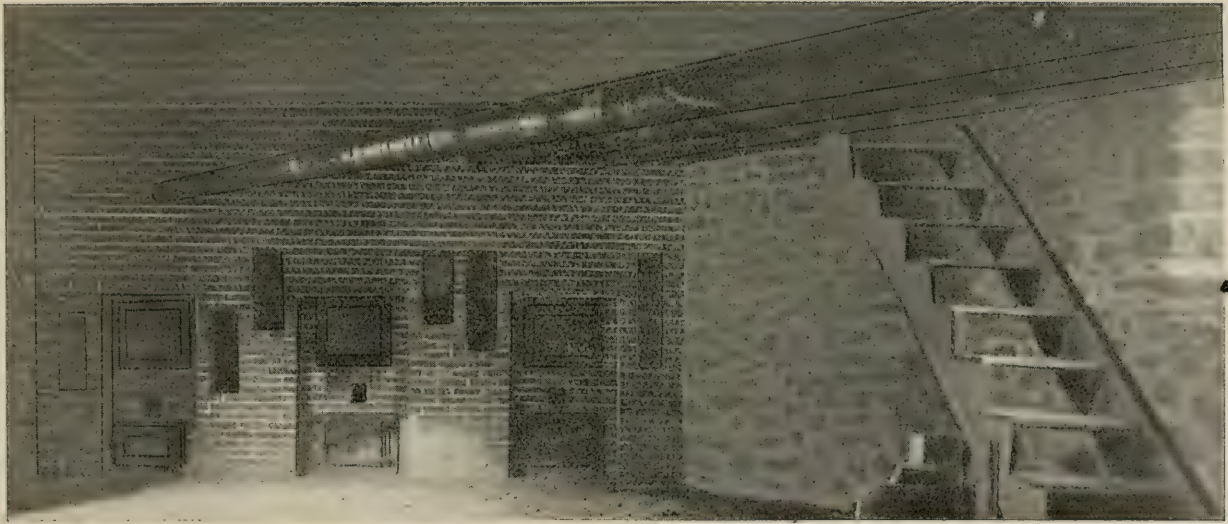
109.—Evaporator of W. H. Bush, Walworth, Wayne Co.

We are now ready to go inside the stack, and we will take Fig. 105 as our guide. The stack is 38 feet high, over all, the wall four inches thick with one coat of plaster on the inside, and the shaft is large enough to admit the regulation size of tray, which is forty-nine inches square. A stack of this size holds twenty-five trays. The back wall of the stack is the blank space bounded by the letters *O Y S* in the diagram *A*. A side wall is shown in diagonal section at the left, bounded by the letters *T E W Y*. The door through which the trays are inserted, on the first floor, is at *W*, and one of the frames on which the trays are rested when they are shoved in, is at *A*. (See the same letters in Fig. 112.) The warming pipes are at *P* (see Fig. 111). The stack passes into the second story at *F*, and the upper door, from which the trays are removed, is at *E*. Above this point, the stack serves as draft-chimney, and as a resting place for the lifting device. The diagram *B* in Fig. 105 shows a direct front view of a cross-section of the stack.

110.—Same as Fig. 109, rear view. Coal shed on the left.

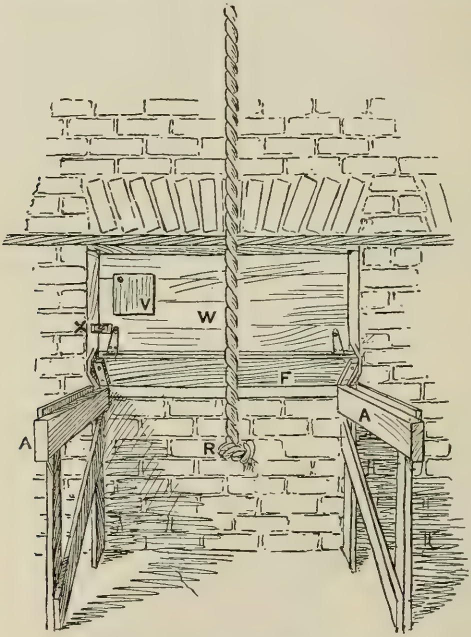
The chief essential in the interior arrangement of a tower is some apparatus for lifting the trays, to allow of a tray of fresh fruit to be placed in at the bottom of the stack. Some of these apparatus work by means of an endless chain run on a shaft and moved by a crank, whilst others work directly by means of a lever. Various lifting devices, some of them controlled by patents (as mentioned in the descriptions of them), are in use in western New York. Some of the most prominent types are mentioned for the purpose, not of recommending any one of them, but to acquaint the reader with the leading principles in the manual operation of an evaporating establishment.

The lifting device by means of which the trays are elevated in the Bush stack (Figs. 105, 109, 110) may be called the Culver-



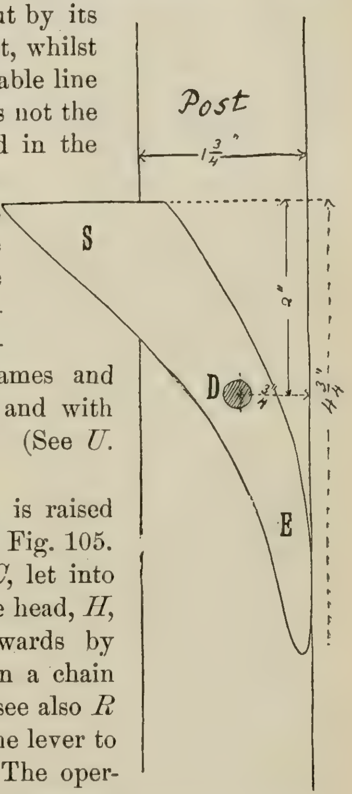
111.—Basement in evaporating establishment of W. H. Rush.

Cassidy or Rogers apparatus. The Culver lifting device consisted of a head-block which was raised by a lever, and it connected with two columns or runs of notched strips on either side of the stack. These vertical strips or bars, with the stationary notches, alternately recede into the recesses of the wall, to allow of the lifting of the trays by one bar and the engaging or holding of them in place by the other. The Culver head-block, which is shown at *H C O*, and the lever at *L* in Fig. 105, was at the top of the stack. Now, the Cassidy lifter worked from the bottom, raising the trays by means of a chain winding on an iron bar which was turned by a crank outside the stack. But instead of resting the trays on stationary cogs or notches, as the Culver device did, the Cassidy apparatus employed movable dogs. In 1881, L. R. Rogers obtained the consent of the interested parties, as he informs me, and combined the two machines, using the head-block of the Culver and the movable dogs of the Cassidy. This type of lifting device is the most popular apparatus now in use in Wayne county and adjoining regions, largely because it is readily adapted to any size or height of tower, and is simple and direct in operation.



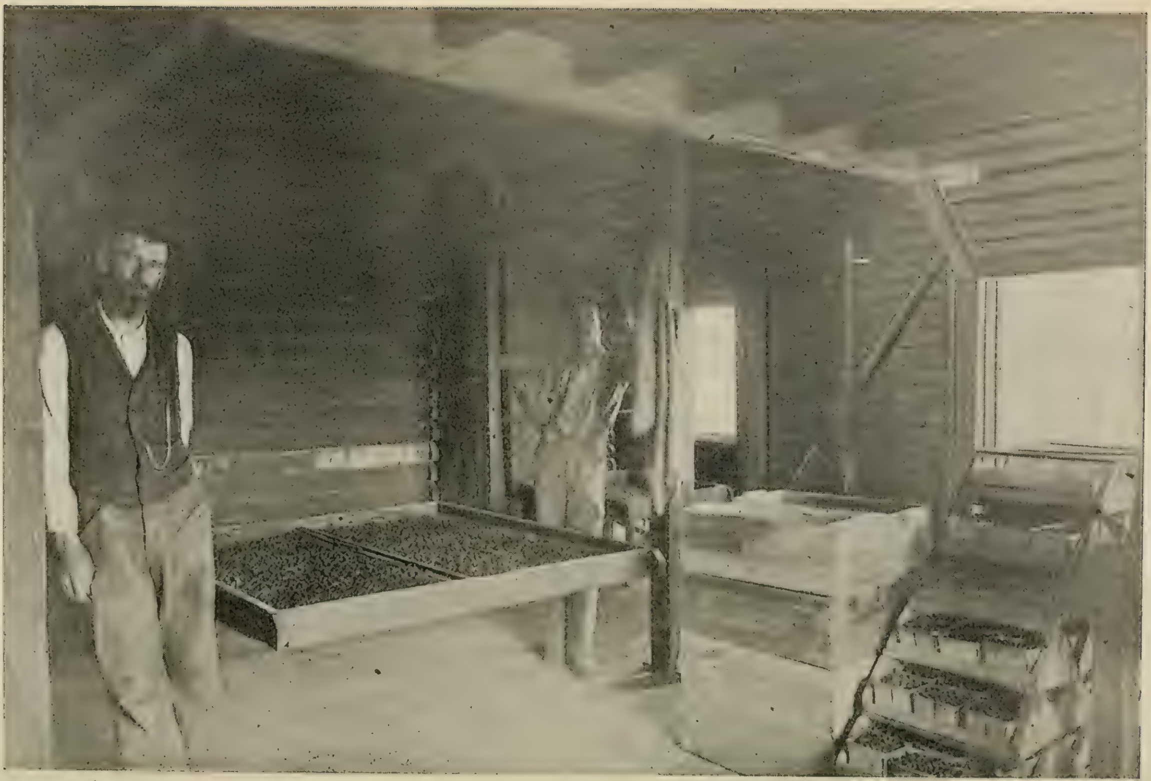
112.—Feeding door of stack.

The lifting apparatus in Fig. 105, therefore, consists of two double runs or columns of dogs on each side of the stack, and a head-block above. The runs of dogs are shown at *N* and at *Y*; also at *S*. One line of dogs in each column is stationary and holds the tray, and the other line is movable and lifts the tray. One of these dogs is seen in Fig. 113. The dog *S E* is a piece of cast-iron, hung on a pivot *D*. There are two of these dogs, side by side. The side of the tray rests on the projecting portion, above *S*. One line of the dogs is raised by the head-block and the tray is lifted with it, the side of the tray, as it rises forcing in the dog above it. As the tray passes the dog, the latter falls out by its own weight and the tray rests upon it, whilst the head-block is let go, and the movable line of dogs falls back to its place. This is not the form of catch or dog which was used in the original Cassidy apparatus, for in that the catches evidently worked by springs and not by gravity. The brief of the original specification called for "the combination of stationary posts provided with spring-catches, with vertically-movable posts carrying drying frames and provided with similar spring-catches, and with mechanism for operating the same." (See *U. S. Gazette of Patents*, ix. 165, 166.)



113.—Dog, or tray rest.

The movable or lifting line of dogs is raised by the head-block, shown at *H O* in Fig. 105. This device is secured to a timber, *C*, let into the brick-work, and through which the head, *H*, plays. The apparatus is moved upwards by means of the lever, *L*, which works on a chain fastened just below *C*. A rope, *R* (see also *R* in Fig. 112), drops from the end of the lever to the operator's hand on the first floor. The operator, therefore, pulls down on the rope, moving all the trays up one notch, thus leaving the lowest notch free for the insertion of another tray. Looked at from beneath, the head-block presents the outline shown in diagram *C*, Fig. 105. The attachment of the block to the lifting-rods is shown in diagram *D* (showing a cross section), and also in *T* in diagram *A*.



114.—The Automatic Evaporator. (Uriah Hair and Son, Dundee.)

While this Culver-Cassidy lifting device is the most common one in western New York, there are still many other styles. The old Alden evaporator, which is now little used, lifted the trays by means of an endless sprocket chain working on a shaft at the bottom and top of the stack, and bearing fixed dogs at intervals to hold the trays. A crank on the lower shaft served to move the column of trays, and the chain returned on the outside of the stack.

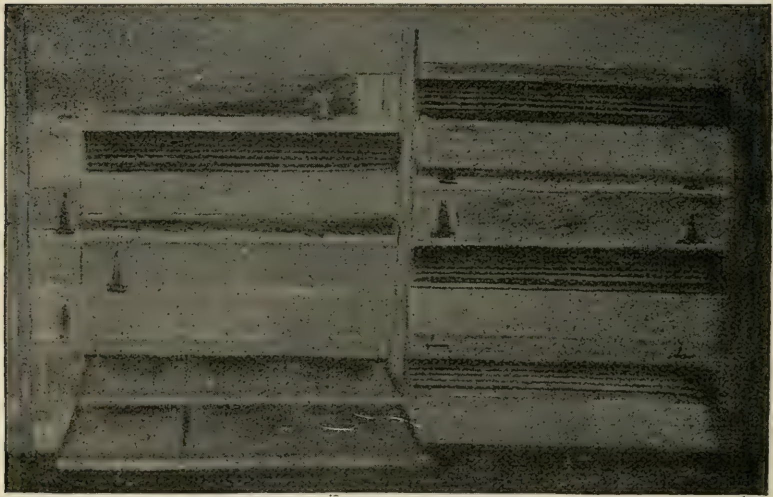
The Williams evaporator works endless chains wholly inside the stack, and the trays are permanently fastened to the chain and are brought back to the feeding door, where the fruit is removed. This saves running up and down stairs with the trays, which is a drawback in the towers already described, and it allows the operator to inspect any tray of fruit at will by turning the crank and bringing it back to the door. The chief disadvantage in the Williams is the fact that the fruit is "finished up" or removed in the hottest part of the stack, instead of being taken out at the top, which is the coolest part of the stack; but this difficulty is reduced to a minimum by filling the stack as full as possible to begin with and then letting the fire go down as the fruit becomes dry.

A tower dryer constructed upon a different principle is the Automatic, made in Philadelphia, and a view of it is seen in Fig. 114. In this machine, the trays themselves fit upon one another and form the stack. The entire pile or stack of trays is lifted by a crank and chain, and a new tray is inserted at the bottom. The illustration shows a tray (five feet square in this case), resting upon the rack and ready to insert at the bottom of the stack of trays.

There are other styles of tower driers which have no lifting devices. The trays slide into slots or rest upon cleats, and they may be taken out and replaced higher up, or the evaporating may be controlled wholly by attention to the heat and to ventilating by opening the doors. Most small evaporators designed for preparing fruit for family use are of this description. Any person who is handy with tools should be able, from all the foregoing account, to make a machine which will evaporate from two to ten bushels of berries or apples a day, and thus be able to save most of the fruit about a small plantation which ordinarily goes to waste. A drier containing ten to twelve trays three feet square should handle ten bushels of apples a day with ease. A small stove may be used for heater, or a brick furnace may be built. Of small cheap driers in the market, the Topping made at Marion, N. Y., and shown in Fig. 106, is much used in Wayne county. This can be had in four sizes, with capacities ranging from five to twenty bushels of apples a day.

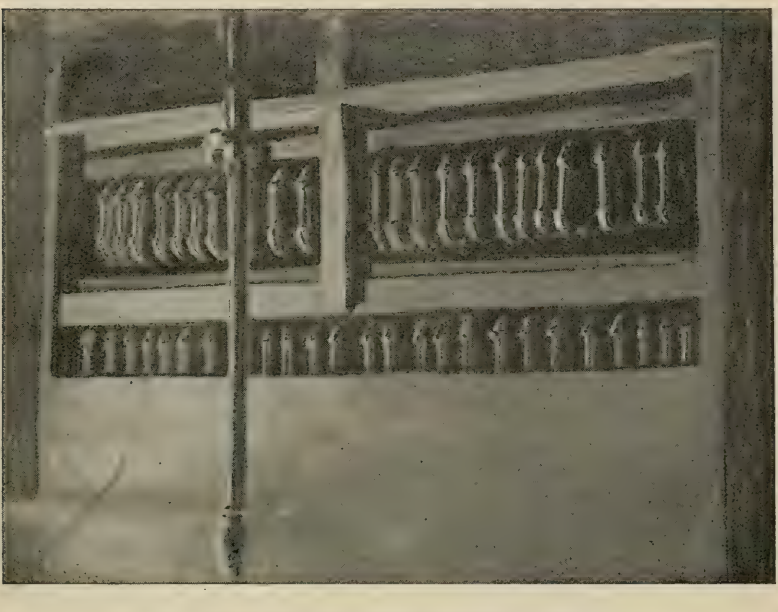
Steam tray-driers.

Steam is occasionally used in kiln driers, as we have seen (page 446), but it is most efficient when applied in closed stacks or boxes, underneath trays. For a very large output, steam is probably the most efficient and economical heat, particularly where light power is also wanted for running parers, cider presses, carriers, and the like; and it also has the advantage of being easily carried to all parts of the establishment for warming purposes. Coils of steam pipe are laid in horizontal tiers, the space between each two tiers being just sufficient to allow of the easy insertion of one or two trays. Each tray is therefore independent of all others above or below it, and it may be allowed to remain in its original position until the fruit is finished. A narrow horizontal door is provided for each space. These tiers of steam pipes may reach a total height of five to eight feet, and several stands of them are usually placed along side, and the whole is usually boxed in with lumber. Fig. 116 is a front view of a portion of two stands of a steam tray-drier. Six doors are shown in each stand, some of them open and dis-



116.—Front view of a steam box (L. R. Rogers, Albion).

closing the piping, and on the bottom at the left two trays are shown, partly drawn out. An end view of one of these boxes is seen in Fig. 117, in which two complete tiers or runs of pipes are shown and also the lower tier, or run, of another double coil. The reader will be interested to know that this description of a steam drier is taken from the establishment of L. R. Rogers, whom I have already introduced in connection with the history of the evolution of the evaporator, but who is now a resident of Albion, where he has one of the most complete establishments in the State. In Mr. Rogers' experience, 4,000 feet of 1-inch pipe gives a capacity of 300 bushels of apples per day.



117.—End view of the right-hand stand of Fig. 116.

The use of steam is capable of almost endless modifications to suit individual circumstances, and it is so completely within the control of the operator, that it must increase in popularity as competition and co-operation increase.

Air-blast driers.

The drying of fruit by means of drafts of heated air has received some attention recently in western New York, particularly in the Blanchard establishment at Albion, but as its use is adapted rather more to large establishments than to the individual grower, I shall not discuss it here.

Methods and results.

As in all other industries, there are all grades of products turned out of the evaporators, the differences being largely attributable to the care and attention which the operator gives to his business. In raspberries, however, with which this paper is concerned, there are fewer differences in grades than in other evaporated fruits, because the fruits themselves do not need any preparation previous to evaporation, and because even a large number of inferior fruits may be lost in the mass.

If one contemplates making a large quantity of evaporated products from year to year, he should give particular attention to the plan of his building as well as of the evaporator itself. A basement is handy for coal and storage, and it contains the heating apparatus. The first floor is the receiving room for the fruit, the office, and either this room or a wing contains the paring machines, bleaching boxes, and other accessories. The second floor affords storage for the finished fruit. This is stored in piles on the floor, and the latter should therefore be made of a good quality of dressed and matched lumber. Nothing is more essential to an evaporating establishment than scrupulous cleanliness, for the refuse of the fruit soon sours and decays and makes the place a most forbidding one, while a well kept evaporating establishment has a most attractive, fruity odor. I am sorry to say that there is opportunity for great improvement in matters of simple cleanliness in very many of the evaporating establishments of this State.

Many of the evaporator buildings are remodelled from old dwelling houses, shops, or other buildings, but they are rarely as handy and efficient as those which are built for the purpose. It should be borne in mind, when building, that the stacks themselves should occupy a comparatively small part of the establishment; that is, the room needed for storage and working much exceeds that needed for the drying towers. This remark is well enforced by the building shown in Fig. 108. The main building, containing three towers in the rear, is seen at the right. It has a capacity of 5,000 quarts of berries a day. The wing partly shown on the left is a storehouse. This outfit can be built for less than $2,000. The

Bush establishment, shown in Figs. 105, 109, 110, 111, is 24x36 ft., with 16 ft. posts, three solid brick stacks 38 ft. high, and stone basement, well finished throughout, and cost $1,400. This establishment has a capacity of about one thousand bushels of apples a week.

The tray most commonly used in Wayne county is a frame 4 ft. 1 in. square, covered with wire screen which has a mesh about one-fifth or one-fourth inch wide. Such a tray receives about sixteen quarts of berries at each filling. A stack of the capacity of Mr. Bush's holds 25 trays, so that the stack has from twelve to thirteen bushels of berries, measured when fresh, when it is full. Mr. Hair (Fig. 114) spreads from twenty-four to thirty quarts of berries upon his 5x5 ft. trays. Under ordinary conditions, with heat about 200° F. at the bottom tray, these trays may be moved up — that is, fresh berries inserted — every 10 minutes. A twenty-five-tray stack, therefore, would be discharged in about four to five hours. The operator will soon find, however, that the time required to finish the fruit varies with many conditions and with the variety of berry. In moist weather and with the first pickings more time is required because the fruit is plump and juicy. For the later pickings and in dry times the evaporation may be completed in half the time required for the plump berries. The Ohio raspberry also dries quicker than most other common varieties. It is, therefore, often necessary to "strip" the trays; that is, to take out five or six or more trays at once, rather than to wait for each one to come out in its appointed turn. A test made by myself in one of the best evaporators of the State finished Gregg raspberries in four hours. The trays were filled with 24 quarts at 11 a. m., with bottom heat 175° and top heat (at upper trays) 100°, the outside temperature being 74°. The fruit came out at 3 p. m., and measured 10 quarts to the tray.

The berries are "finished" when they are dry enough to rattle a little on the trays. The trays are then removed and "scraped" with a wooden paddle into a bin or pile on the floor. As they come from the tray the berries are still moist and soft, and will stick to the palm if squeezed in the hand. That is, they are not yet dry enough to keep. They must now be cured, by allowing them to rest in piles six to eighteen inches deep in the warm, airy chamber, and by shoveling them over several times in the course of a few weeks. It will generally be necessary to turn them over from six to twelve times. This curing of the berries is more often slighted than the drying of them, in my observation, and buyers often complain of the softness of the product. When the berries come from the trays they are commonly very unequal in size, some having dried out more completely than others, but as they lie in the bins the small berries absorb some of the moisture from the plump ones, the latter thereby becoming smaller, and the product finally comes to be very uniform in size, as shown in the sample, which is a good one, in Fig. 118. At this stage, when the product goes to market, the berries should not adhere to the palm when they are pressed in the hand. The product is run through a fanning mill and is then packed in barrels for shipment. A barrel holds about 125 pounds of dried berries.

118.—Evaporated raspberries fit for market. Four-sevenths natural size.

The amount of fresh berries required for a pound of the cured product is a variable quantity. In the test just cited 24 quarts gave 10 quarts, but these were fresh from the trays, and further shrinkage took place before they were fully cured. On an average, a little over three quarts (about four pounds) of fresh blackcaps are required to make a pound of marketable product. In a moist season four quarts are usually required. At the end of the season, when the berries are small and dry, two quarts may make a pound. Of red berries, from four to five quarts are required for a pound of evaporated fruit.

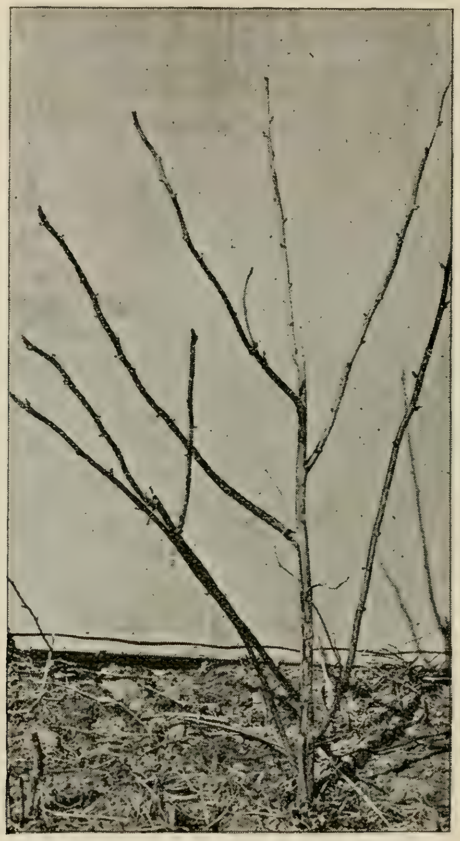
The staple variety of blackcaps for evaporating is the Ohio, although the Gregg is crowding it out — and properly so, I think

— in many of the best berry sections. There are no close competitors of these two varieties for evaporating purposes. The red varieties are seldom evaporated, because there is little demand for the product, they consume much time on the tray, and too many berries are required to make a pound. Shaffer is more frequently dried, although it has no conspicuous place in the industry. A fuller account of these varieties will be found in Part II.

When evaporated raspberries were first put upon the market they brought prices which would fairly intoxicate the sober berry growers of these days. Thirty to forty cents a pound were common prices, but these were clearly in excess of the value of the goods, and prices fell and production increased. For the last three or four years the price has probably averaged about sixteen or seventeen cents a pound. The demand is brisk. There is profit in dried berries at this figure if the grower secures a good crop; but there are patches enough in which twice this price would not leave sufficient margin to be worth the counting. With the figures which I have given and allowing 1½-cent per pound for the drying of the blacks and 2 cents for the reds, the grower can figure out the yield which he ought to have to secure him the profit which he wants.

II. THE FIELD.

The farmer must grow his berries before he dries them, and he oftener fails in the former than in the latter operation. It will not be necessary to enter into many details of the cultivation of the raspberry, for its treatment is simple, only requiring close attention. Land known as good wheat or corn land is always suitable for the raspberry. The remarks in Bulletin 99 respecting land for the blackberry, as well as methods of training and pruning, will apply almost equally well to the raspberry; and the same may be said of the directions for winter protection, although it is rarely, if ever, necessary to protect the bushes in western New York. Black raspberries are usually headed back when from 1½ to 2 feet high. It is important that this heading-in be done about as soon as the canes reach the desired height, rather than to leave them until considerably higher and then to cut them off to the required point, for the laterals then start low and the bush becomes stout and self-supporting. It is a very general mistake to head back raspberries too late or too high, causing the laterals to start nearer the top of the cane and thereby making it top-heavy. Fig. 119 is a good cane of Cuthbert, and Fig. 120 shows several undesirable canes of the same variety. The laterals are cut back the following spring to a length of 12 to 18 inches, the same as blackberries are. This treatment also applies to the purple-cane varieties, like Shaffer, but not to the reds, for these are rarely headed-in at all.



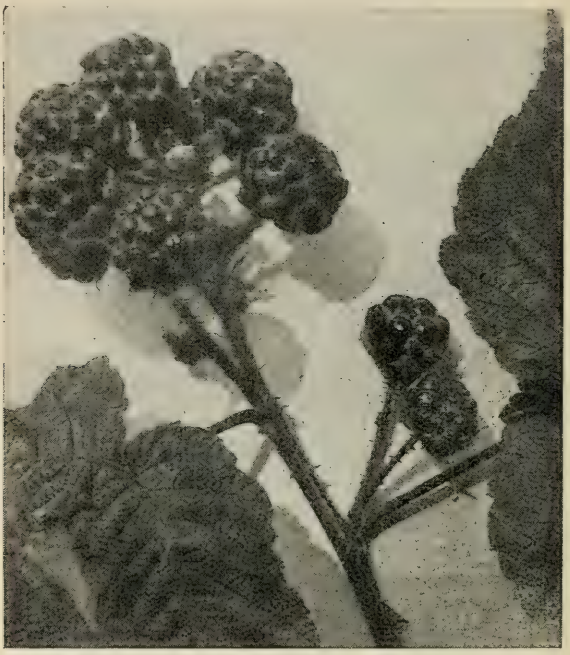
119.—A good cane of Cuthbert, with low laterals.

The red raspberries are very seldom evaporated, and only the Cuthbert is used for that purpose, so far as I know. The red berries generally pay better when given to the open market. Of the purple berries, only the Shaffer is dried in western New York, and it is doubtful if it is profitable when thus handled, for it loses too much in drying and the market for dried red and purple berries is very small. The new Columbian raspberry impresses us very favorably, and if it behaves in other places as it does on our own grounds it must crowd out the Shaffer. It is rather more vigorous in growth than the Shaffer, has a longer season, and the berry is more conical and firmer, with more uniform drupelets.

120.—Poor canes of Cuthbert, with high laterals.

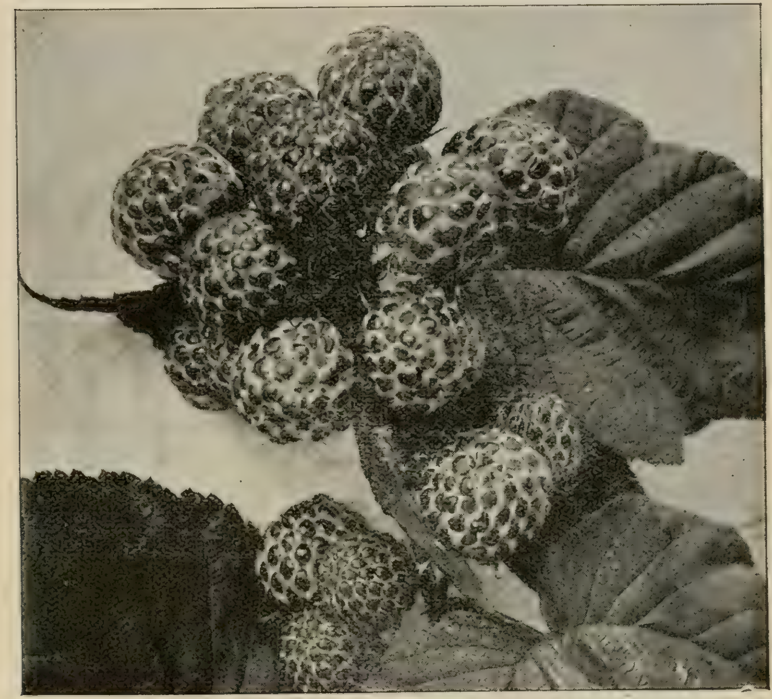
There are really only two important varieties in the evaporating industry in western New York, the Ohio and the Gregg. The Ohio is valuable because it is easily grown and the berries are firm and "seedy" and therefore dry easily. It is still the dominant berry in northern Wayne county, but it is gradually losing ground in the southern part of the county and in Yates county. It seems to be running out, largely, perhaps, because the stock is coming to be diseased with the yellows or red rust; and it is possible that land may enjoy a rotation even amongst varieties of the same species.

It looks to me as if some other berry, of better quality and larger size, is bound to drive it to the wall. The only other strong competitor at the present time, as I have said, is Gregg. The Gregg is exceedingly valuable because it demands rather better land and better culture than that under which the Ohio will thrive. It therefore has a salutary effect upon the grower. Given this good care, it is an abundant and sure cropper, producing berries like those in Fig. 122.



121.—Ohio type of raspberry. Life size.

How long is it profitable to crop a raspberry patch? Rarely more than three or four crops. Growers are all the time making the mistake of letting the patch stand "just one year longer," thereby encouraging poor cultivation and inviting the spread of yellows, anthracnose, and other wandering guests. The plants or tips are set, say, in the spring of 1893. The small canes which spring from the crown that year will bear some berries in 1894, when they are called "creepers," because they lop over on the ground whilst the strong canes of 1894 stand erect. In 1895, the crop borne on the canes of 1894, should be heavy. In 1896, the crop is generally less, and after it is off, the bushes may be pulled out and the land fitted for other crops. Berries ought not to be set upon this land again in less than three or four years. There are many instances in which the plantation can be left for the fourth or fifth crop with profit, but they are patches which have not become foul with grass, thistles and diseases, and which have had good attention throughout. The good culture it is necessary to give the Gregg may prolong the life of the patch a year or two beyond this estimate. In extensive travels in western New York, I have been looking for the model commercial black raspberry plantation. My choice is shown in Fig. 123, which shows a patch of Gregg bearing the first full crop, and owned by T. G. Yeomans & Sons, Walworth, Wayne county.



122.—Gregg. Life size.

How much will an acre of raspberries produce, taking the average of three crops? Opinions differ widely. We could begin with zero on the one hand, and rise to 6,000 quarts. In an inquiry made

123.—A model plantation of Gregg raspberry. (T. G. Yeomans & Sons, Walworth.)

here in 1893,[*] the average of 58 replies of berry growers was 2,493 quarts. One gave his yield (which must have been on a small patch and amply multiplied) as 9,900 quarts, whilst another confessed to but 576 quarts. A good yield for the second crop is 3,000 quarts, or 90 to 100 bushels per acre. Willis P. Rogers tells me that his largest field crop of Ohio, the third year after planting, was 16,000 quarts on four acres, and a half acre of this land was not up to the standard. From extensive inquiries of evaporator men, however, I find it to be a general opinion that the average crops of the country, one year with another, will not exceed 1,200 quarts per acre, or 300 pounds of dried product.

The harvesting of the crop costs too much. The price paid by evaporating men this year for Ohios and Greggs was 4½ and 5 cents a quart, yet the grower generally had to pay 2 cents a quart for picking. Here is an advantage of the Gregg, for pickers can generally do as well in picking it for 1½ cents as in picking the Ohio for 2 cents. To lessen the cost of harvesting and to overcome the difficulty of securing pickers in remote places, the berry harvester has come into use.* This is a canvas tray, made by stretching the cloth over a light wooden frame about three feet wide and four or five feet long. At the bottom, the frame projects upwards at right angles to the body of the frame to a distance of five or six inches, to catch the berries as they fall upon the canvas. A wooden shoe or runner is placed on the bottom of the apparatus to allow the operator to slide it along from bush to bush, as shown in Fig. 124. A long wire hook (Fig. 125) is used to pull the bushes over the tray or to lift up the fallen canes, whilst with the other hand the operator deftly cuffs off the berries with a paddle of wood or of wire covered with canvas and about the size of a butter ladle.

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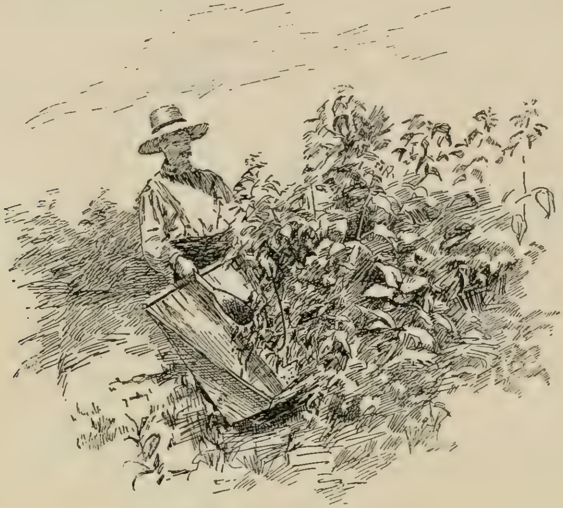
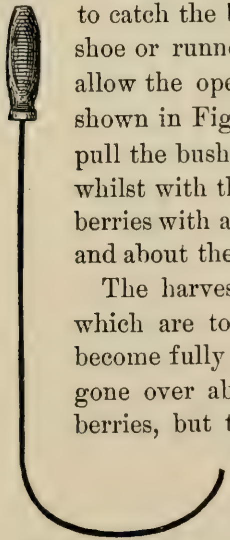
[*] Bulletin 57, "Raspberries and Blackberries," by Fred W. Card.


124.—Batting the berries.


125.—Batter's hook.

The harvester is used only for the gathering of berries which are to be evaporated. The berries are allowed to become fully ripe, so that they fall easily, and the patch is gone over about three times. Much litter falls with the berries, but this is readily removed by running the dried fruit through a fanning mill. There are few growers who use this harvester exclusively. It is often brought into requisition for the last picking, and it also has a most stimulating effect upon a lot of disaffected berry pickers. The device was first perfected by Mr. Benedict, of Dundee, although the idea seems to have originated with Uriah Hair, of the same place.

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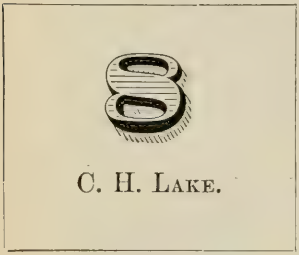
*Fully described in our Bulletin 57, 1893.

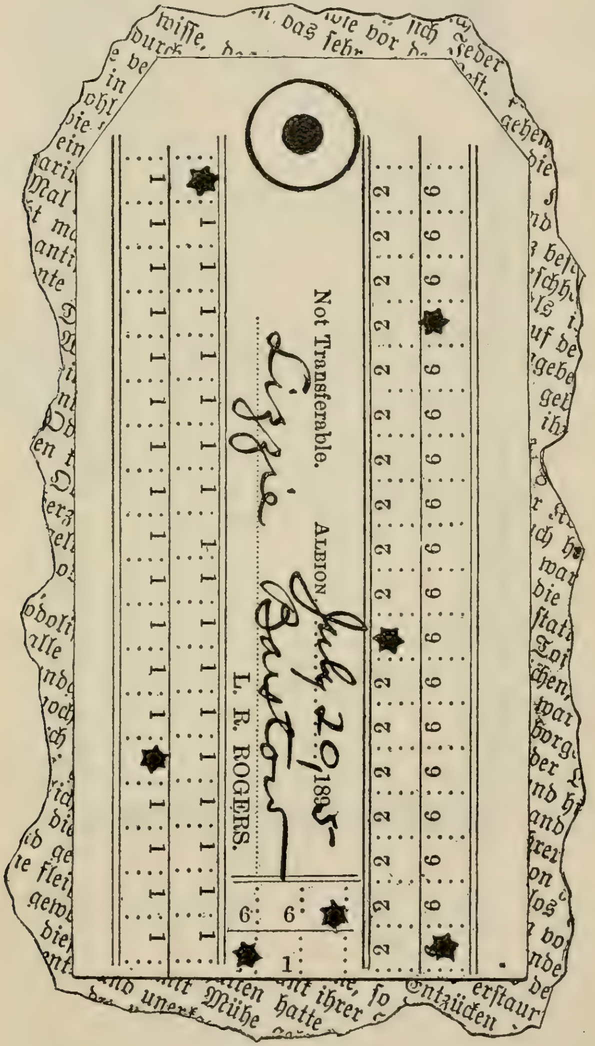
There are various methods of keeping accounts with berry pickers. Perhaps the commonest mode in large patches is a simple ticket. like Fig. 126, which is given to the picker in exchange for the berries which are delivered. There are tickets of various denominations, the figures representing quarts, so that any number of quarts can be represented by combinations of tickets. These tickets are so often lost that they may soon come to be a nuisance. Several growers, therefore, have designed tickets which can be tied to the person by a string, which bear the picker's name, and in which the numbers are cancelled by a punch. Two good styles are shown, full size, in Figs. 127 and 128. In the latter are two styles of punch marks, representing different foremen. Other growers abolish all ticket systems outright, and keep a book account with each picker. The Yeomanses, at Walworth, do this, and what is better they pay by the pound. A small flat-topped grocers' scale is taken to the shed in the berry field. Each picker is numbered, and he picks in an eight-pound Climax grape basket. As he comes to the shed, he slips his number into the basket on a bit of card or splint, and he sees the basket weighed and the credit given; or, if the picker has no suspicions, the foreman may gather the baskets from the field. They pay 2 cents a quart, or 1.6 cent a pound (since a quart weighs $1\frac{1}{4}$ pounds), but the price can be dropped to 1 cent a pound in Greggs.



126.—Picker's ticket.

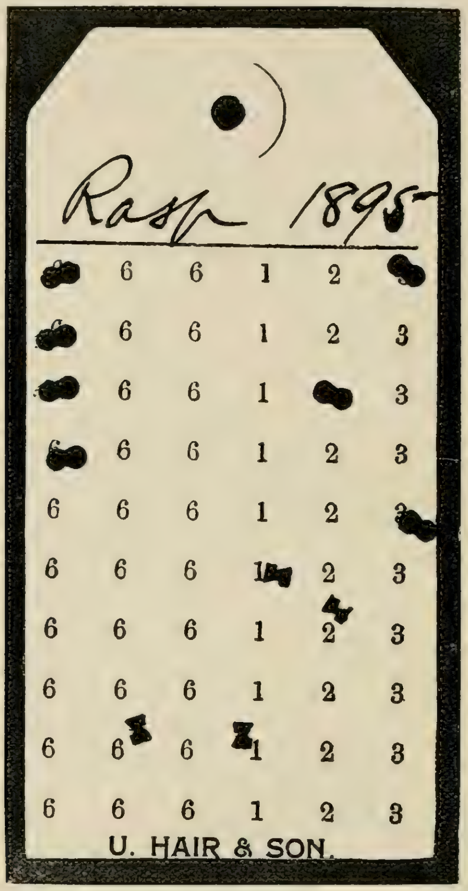
A word may be said, in passing, about berry stands. The best one which I know is the Dundee stand, shown in Fig. 129. This holds six quart boxes. It is strong, and of handy shape; but its chief merit is the ease with which the stands can be stacked without injuring the fruit. See the stack of them at the right in Fig. 114. A commoner style is a six-basket stand on four legs, one being shown in front of the man in Fig. 123.

After all is said and done, how much of his crop shall the grower evaporate? Mr. Hair says that when the price of berries goes below eight cents a quart, the berries go into the evaporator. Mr. Yeomans puts them in the evaporator when they fail to net seven cents a quart. An efficient evaporator upon any place, even though it be a very small one, has a good effect both upon the market and upon the grower. It keeps a surplus of green fruit off the market, and it informs the buyer that he must keep his price above water level or he can not get the fruit. On the grower's part, it makes him in a measure independent of the market; but more than that, it leads him to save much of what is generally a waste product,



127.—Picker's tag.

such as windfall apples, surplus berries, and the like. It is unquestionable that much of the prosperity of Wayne county and adjoining regions is attributable to the garnering evaporators which are the property of so many farms.



Rasp 1895

6	6	6	1	2	3
6	6	6	1	2	3
[illegible]	6	6	1	[illegible]	3
6	6	6	1	2	3
6	6	6	1	2	3
6	6	6	1	2	3
6	6	6	1	2	3
6	6	6	1	2	3
6	6	6	1	2	3
6	6	6	1	2	3

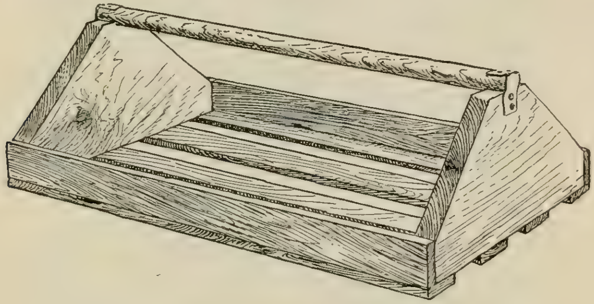
U. HAIR & SON.

128.—Picker's tag.

Diseases.

The grower will want to hear something about diseases of raspberries before I am done, by way of dessert. Then, I will first observe that I am glad that they exist. All education and progress come of difficulties. The perplexities drive the weak and incompetent persons out of any business, and make students of the remainder. The bugs and fungi are good teachers, for they make us learn whether we will or no. Then I am pleased to report three vigorous diseases which are invading the raspberry plantations of western New York, but all of which can be kept in check by digging out the bushes or by cutting them off and burning the brush. This may seem to be heroic treatment, but one who begins it with the very first symptom will generally suffer very little loss; and the practice in keeping his eyes open will make him a better berry-grower all around.

Yellow, *red rust* or *orange rust*, is the disease best known to growers. This disease is generally known by the very thick orange-red covering of spores on the under surfaces of the leaves in early summer. These leaves curl when badly affected (Fig. 130), and make the diseased plant conspicuous at a considerable distance. This stage of the disease is often seen on wild bushes of raspberries, blackberries and dewberries. The sharp berry-grower, however, does not need to wait until this discoloration appears for the young canes on affected plants are slender, cylindrical, and usually wholly destitute of prickles. The botanist is able to detect the disease upon the first unfolding leaves. This malady permeates the entire plant, and is therefore incurable when once established. The orange-discolored leaves fall in early summer, and the plant may appear to recover later in the season, but the following year the plant will be found to be weaker and probably wholly worthless, and the orange coating will return. It is now known that another disorder which makes spots on the under surface of raspberry and blackberry leaves (and known as *Puccinia Peckiana**), is really a



129.—Dundee berry stand.

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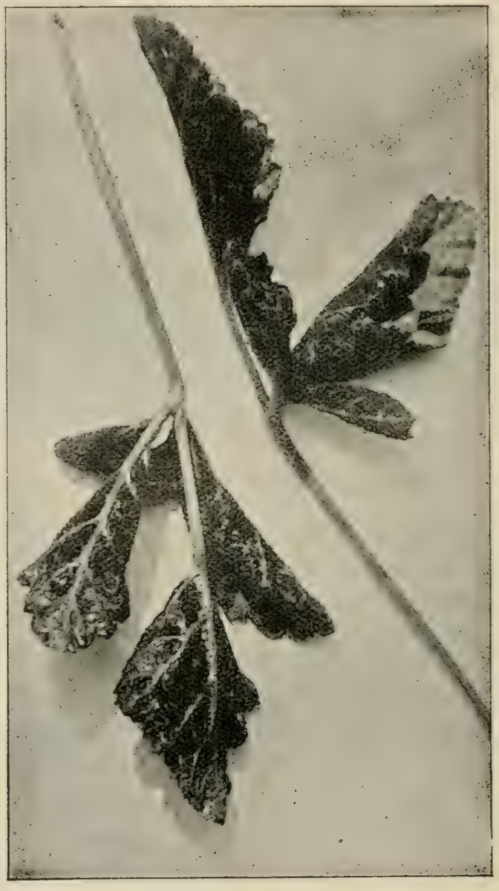
*In some unaccountable manner, probably through an error in "make up," the statement is made in the third edition of my *Horticulturist's Rule-Book* (page 70), that this fungus is a form of the anthracnose.

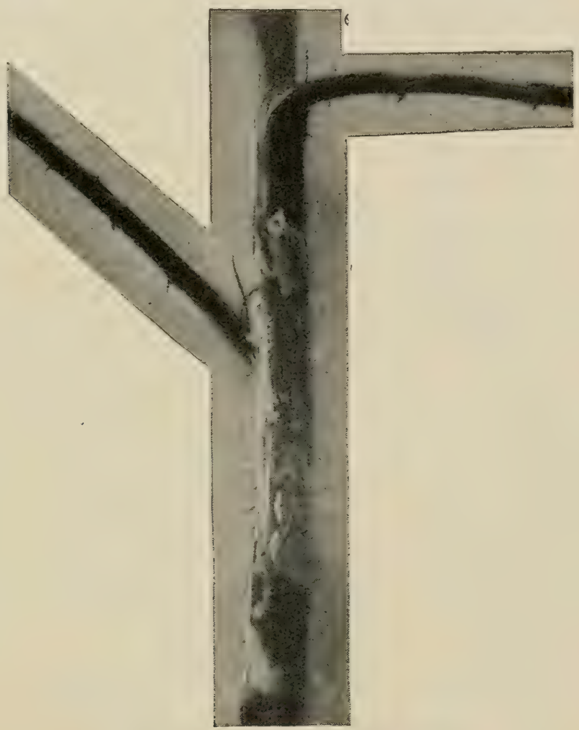
form of this red rust fungus. The spores of this form mature in the fall, and these, falling on the ground, are probably the means of inoculating the plant with the rust through young underground shoots. The red rust form of the fungus is known as *Cæoma nitens.*



130.—Leaves diseased by yellows.

It is evidently useless to endeavor to cure or to treat this yellows or red rust. The first moment the disease is detected, the affected plant should be pulled out, root and branch, and burned. If one is alert, it is generally an easy matter to keep a patch free of the disease. I know of no disease of fruit plants the presence of which is such an infallible indication of neglect as this.

Anthracnose or *cane-rust* is much more to be feared than the yellows. It is less apparent on the plant, and it may spread into all portions of the patch before it is detected. The form of the disease which the grower needs to be able to recognize is shown in Fig. 131. There are various pits or scars on the young cane, each one probably a distinct infection of the disease. These discolored pits interfere seriously with the health of the plant, causing the leaves to turn yellow and the canes to die if the trouble is extensive. Much of the drying up of berries on the bushes is due to attacks of anthracnose on the canes or near the clusters, and some of the death of plants commonly ascribed to winter-killing is attributable to the same cause. The disease is particularly bad upon the blackcaps and the Shaffer. It first appears very early in the season upon the newly starting shoots, and it generally continues to attack the shoots as they increase in height. The first indication of the attack which the grower will notice is the presence of small purplish discolorations on the canes. The disease also attacks the leaves.


131.—Anthracnose on raspberry cane.

It would seem as if the disease could be prevented by keeping the growing canes covered with Bordeaux mixture. If this is tried, the fungicide should be applied whilst the shoots are less than six inches high, and the application must be repeated every week or ten days until the cane has grown to a height at which the disease will not injure it. Green has been able to keep plants free from the disease with both Bordeaux mixture and ammonical carbonate of copper.* He advises for sprayings, one of them before growth begins, and the last just before blossoming time. Beech has had similar results.† The bushes were sprayed six times. Late in November, an examination showed that "the canes in the treated rows were nearly free from disease, while those that were not sprayed are still very badly affected."

Mr. L. T. Yeomans, Walworth, made a similar test this year under our suggestions, upon Gregg. He sprayed with Bordeaux mixture as follows: May 16; May 20 (repeated this early because the first spraying seemed to have hit the leaves more than the canes); May 29; June 7th. On newly set plants, these applications were made, and also the following additional ones: June 13th; June 17th; June 26th; July 9th. These applications were made carefully and thoroughly, but neither Mr. Yeomans nor myself could detect any immunity from disease on the sprayed plants. It should be said, however, that the disease was slight upon all the plants.

My associate, Mr. Lodeman, made a similar experiment this year in the University gardens, and his account follows: "Two varieties of raspberries were selected, Schaffer and Ada, one part of the rows being repeatedly sprayed with Bordeaux mixture. The first application was made May 18th; this was followed by others on June 13th, June 26th and July 11th. The plants and canes were each time deluged with the mixture to such an extent that they lost their normal green color and appeared as blue as the mixture could make them. It was found that the canes could not be nearly so well protected as the leaves, as the liquid refused to adhere to the glaucous surface; it collected, however, upon the ends of the thorns, giving them a marked blue tip.

"Some plants of both varieties received only the two applications made in June, while certain Shaffer plants remained untreated.

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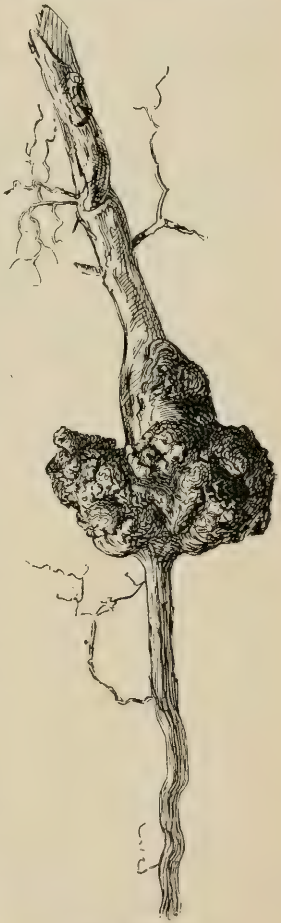
* Bull. 6, Vol. iv. Ohio Exp. Sta. 119 (1891).

† Bul. 81, New York State (Geneva) Exp. Sta. 592 (1894).

Notes taken August 2d and 28th, show that the fungicide had been of some value in checking the anthracnose, but the effects were not so marked as was desired. The canes of the unsprayed Shaffer were very much pitted, the older and larger ones being considerably swollen and bent in places. The smaller canes as well as the leaves also showed an abundance of infected places. The portion of the rows which received the two treatments in June were not in much better condition than the untreated plants. The lower portion of the canes were severely attacked, and although the number of pits did not appear to be so abundant, still all parts of the plants were more or less affected. The bushes receiving the greatest number of treatments were the most healthy, but the benefits derived from the fungicide were not sufficiently marked upon either variety to encourage a grower to repeat the same line of treatment. Some protection was undoubtedly afforded and the plants were plainly in better condition than their untreated neighbors, yet the use of the Bordeaux mixture during the growing season can not be recommended as being of much practical benefit. If the bushes are to be sprayed, the first application should be made as soon as the new canes appear, and these should be kept covered as well as possible. If some more adhesive material than the Bordeaux mixture were employed, better results would probably follow."


132.—Root-gall.

These various results are conflicting. For myself, I do not believe that spraying alone is sufficient to keep down the anthracnose. The very first requisite to clean patches is a short rotation. Remove the plants just as soon as they become weakened, either from anthracnose or age. Next, thin out the young canes and exercise care to remove and burn those which are most diseased. Third, cut out and burn the old canes just as soon as the fruit is off. These three operations are essential to the best raspberry culture anyway, and if the anthracnose succeeds in enforcing them upon the attention of growers, its mission will have been fulfilled. If, therefore, a patch became very badly diseased, I should pull it out; or if that were too violent, then I should mow off the bushes in fall, burn all the brush, and the following year, soak the new shoots with Bordeaux mixture as they grow. By sacrificing a year it might be possible to eradicate the disease. But I am sure that it can be kept in check by attention to the three operations which I have mentioned.

Root-galls (Fig. 132), are often found on raspberries. They have not been carefully studied and the origin of them is not understood. The commonest form is apparently not the work of insects, but is likely of similar nature to the galls which infect the roots of the peach,* pear, and other fruits in New York State. The first indication of their presence is a general enfeebling or yellowing of the bush. If there are no visible injuries of insects or fungi above ground, pull up a bush and examine the roots. If galls are found, make another patch at once on new land.

There are various other diseases and a number of insect pests of the raspberry, but there are few of them which should give serious trouble to the person who has carefully followed the teachings of the experiment stations.

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* See our Bulletin 76, page 389, Fig. 12.

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(Practice short rotations, thin out the young canes, choosing those which are diseased, and cut out and burn the old canes as soon as the fruit is off. In addition to this, frequent spraying with Bordeaux mixture may help matters.)

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(The bushes become feeble and yellow and do not bear. Destroy them, and plant on land which has not had a recent stand of blackberries or raspberries.)

L. H. BAILEY.

BULLETIN 101—September, 1895.

Cornell University—Agricultural Experiment Station.
HORTICULTURAL DIVISION.

NOTIONS ABOUT
THE SPRAYING OF TREES,
WITH REMARKS ON
THE CANKER-WORM.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

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94. Damping-Off.
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97. Entomogenous Fungi.

On account of the technical nature of Bulletin 97, only a limited edition was printed for the use of Experiment Stations and Exchanges.

98. Cherries.
99. Blackberries.
100. Evaporated Raspberries in Western New York.
101. The Spraying of Trees; with remarks on The Canker-Worm.

Cornell University,
Ithaca, *September* 30, 1895.

Honorable Commissioner of Agriculture, Albany:

Sir.—I submit this essay for publication under Chapter 230 of the Laws of 1895. It is no part of its purpose to present any consecutive discussion of the subject of spraying, but it seeks to answer the commonest types of questions which the fruit-raisers of the State have asked me during the past season. The results of various experiments upon spraying will be published later by my associate, Mr. Lodeman.

L. H. BAILEY.

THE CANKER-WORM AND SPRAYING A HUNDRED YEARS AGO.

This worm is produced from the eggs of an earth-coloured bug, which having continued under ground during winter, passes up on the bodies of apple trees early in the spring. They are hatched as early as the end of May, and are so voracious, that in a few weeks they destroy all of the leaves of a tree, prevent its bearing for that year, and the next, and give it the appearance of its having been burnt. As the perspiration of trees is stopped by the loss of their leaves, they sicken and die in a few years.

The worms let themselves down by threads in quest of prey, like spiders; by means of which, the wind blows them from tree to tree; so that in a close orchard, not one tree will escape them. But trees which stand singly are seldomer infested with these insects. As they are the most pernicious kind of insects with which Newengland is now infested, if any person could invent some easy, cheap, and effectual method of subduing them, he would merit the thanks of the publick, and more especially of every owner of an orchard.

Several methods have been tried, with some degree of success: 1. Tarring. A strip of canvas, or linen, is put round the body of a tree, before the ground is open in the spring, and well smeared with tar. The females, in attempting to pass over it, stick fast and perish. But unless the tarring be renewed every day, it will become hard, and permit the insects to pass safely over it. And renewing the tar in season is too apt to be neglected, through hurry of business and forgetfulness. If birdlime were to be had, it might answer the purpose better, as its tenacity will continue for some time. 2. Some tie straw round the bodies of the trees. This serves to entangle and retard the insects, and prevents the ascent of many of them. But they are so amazingly prolifick, that if ever so few of them get up, a tree is greatly damaged, at least for an ensuing season or two.

The pasturing of swine in an orchard, when it can conveniently be done, I suppose to be an excellent method. With their snouts and their feet, they will destroy many of the insests, before they come out of the ground, or while they are coming out. And I have never known any orchard, constantly used as a hog pasture, wholly destroyed, or even made wholly unfruitful by these worms. But this method cannot always be taken; and if it could, I do not suppose it would be quite effectual. When the trees are young, the swine will be apt to injure them by tearing the bark.

There are several experiments I could wish to have tried, for subduing these insects: Such as burning brimstone under the trees in a calm time;—or piling dry ashes, or dry loose sand, round the roots of trees in the spring;—or throwing powdered quicklime, or soot, over the trees when they are wet;—or sprinkling them, about the beginning of June, with sea water, or water in which wormwood, or walnut leaves, have been boiled;—or with an infusion of elder, from which I should entertain some hope of success. The liquid may be safely applied to all the parts of a tree by a large wooden syringe, or squirt.

I should suppose that the best time for making trial of these methods would be soon after the worms are hatched: For at that stage of their existence they are tender, and the more easily killed. Sometimes a frost happening at this season destroyed them. This I am told was the case in some places in the year 1704.—*Samuel Deane, D. D.* (*Vice-President of Bowdoin College*), *The Newengland Farmer, or Georgical Dictionary, Second Edition,* 1797.

1. The Spraying of Trees.

SPRAYING has now come to be an established part of the work of fruit-growing. With all that has been written upon the subject, the fruit-grower should now be competent to perform the ordinary spraying of his trees without further advice. It is not my purpose, therefore, to enter into any detail respecting the general methods of spraying, but rather to set down some disconnected hints and observations which have suggested themselves to me in a somewhat extensive inquiry into the conditions of fruit-growing in western New York, and which appear to have received only incidental or minor attention from writers upon spraying.

1. *Spraying is only one of the requisites to success in fruit-raising.*—Spraying has come into use so quickly, and so much of the attention of teachers and experiments has been given to it, that many people have come to look upon it as the means of salvation of our orchards. If spraying is to have the effect of obscuring or depreciating the importance of good fertilizing, then it might better never have come into being. Trees must grow before they can bear, and this growth depends upon food and proper conditions of soil, more than it does upon the accident of immunity from insects and fungi. There are four fundamental operations upon which all permanent success in most kinds of orchard culture depend, and I think that their importance lies in the order in which I name them,—tillage, fertilizing, pruning, spraying. Spraying is the last to be understood, but this fact should not obscure the importance of the other three.

2. *Spraying is an insurance.*—There are always elements of risk in the growing of fruit. The chief of these is frost, a difficulty which will never be completely under our control. The second great element of risk is the injury wrought by insects and fungi, and the greater part of this injury can be averted by the sprays. Now, it is impossible to foretell by any considerable length of time, if any or all of the difficulties which are liable to harass the fruit-

raiser will actually appear. One does not know if his buildings will burn, yet he insures them. We know that in four years out of five some serious injury of insects or fungi may be confidently expected, and it is the part of wisdom to insure against it. Last year, 1894, was a season of remarkable invasion of apple-scab fungus, and those persons who sprayed their orchards thoroughly had phenomenal results. These experiences, aided by many publications upon the subject, so advertised the value of the sprays that much more spraying was done in the State this year than ever before. But it has so happened, probably because of the dry spring, that comparatively few invasions of enemies have occurred this year; and the sprays have, generally, given small results. There has now arisen, therefore, considerable indifference, or even opposition, to spraying, and I expect to see much less of it next spring than I saw this spring. If, then, next year should be prolific in insects and diseases, there will be a few orchards here and there which will reward the forethought of the owner, and very many others which will be monuments of the results of neglect. It is a common fault with farmers that they draw their conclusions from the behavior or experiences of each recurring season, and do not consider the aggregate results of a series of years. Every operation should rest upon some fundamental reason or philosophy, rather than upon any single half understood experience.

A fruit-grower wrote me as follows last July:

"You are always advising people to spray their orchards. All my neighbors spent much time and money last spring in spraying, but I did not spray and my fruit is just as good as theirs."

"I do not doubt your experience," I replied; "this has been a dry year, and there has been little scab fungus. But you should have insured your orchard against probable loss by spraying it."

A few days later, the same correspondent wrote again: "We have had a heavy rain, but it seemed to be poisonous to my potatoes and they are all blackened and wilted. What shall I do?"

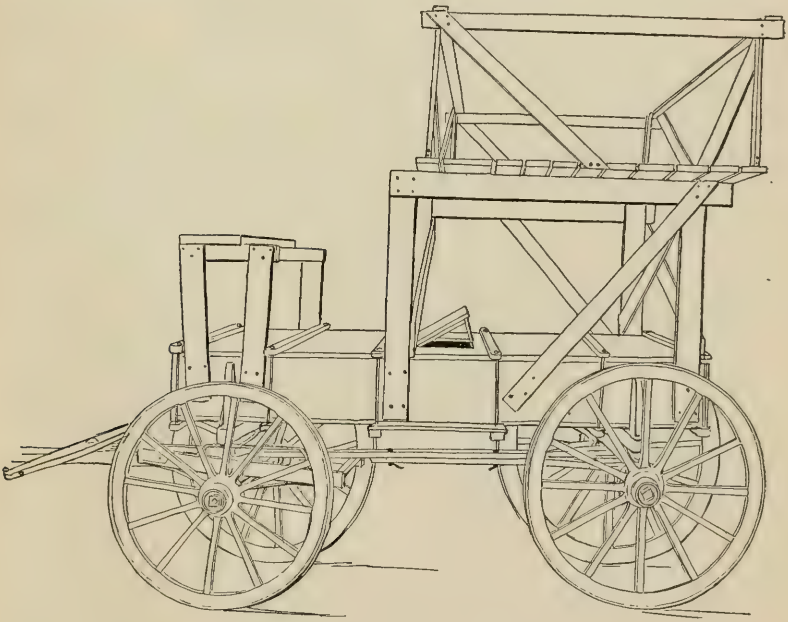
I hope that there was no feeling of sarcasm in my reply:

"I am sorry to hear of your loss, but it is now too late to avert the calamity. Your potatoes were not insured."

3. *Spraying is of some value every year, upon apples, pears, plums and quinces.*— Even this year, nearly all the sprayed orchards are carrying a better foliage than those which are untreated, and where codlin-moth, bud-moth, case-bearer, and other insects are

plenty, it has been of decided benefit. So, wholly aside from the idea of insuring against risk, it is advisable to spray for those insects which are more or less abundant every year. Some insects and diseases appear late in the season, so that in a year like the present the spray may be needed at some epoch in the season. We had marked success in spraying quinces last year (Bulletin 80), but we have had better results this year. But I am not urging people to spray their orchards. Those persons who will not spare the trees this much of their attention will not be likely to do much in the way of tilling and fertilizing. One must grasp the entire body of principles of orchard management before he can hope for permanent rewards.

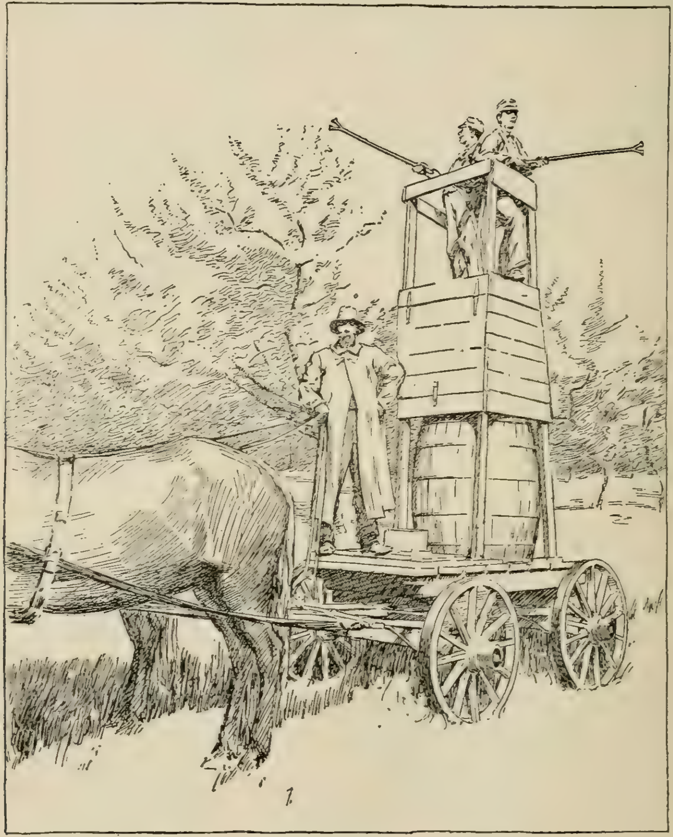
4. *Spray thoroughly, or not at all.* — I should say that fully half the spraying which I have seen in western New York in the last two or three years is a waste of time and material. Squirting a few quarts of water at a tree as you hurry past it, is not spraying. A tree is thoroughly and honestly sprayed when it is *wet all over*, on all the branches and on both sides of all the leaves. An insect or a fungus is not killed until the poison is placed where the pest is.



133.—Spraying rig of T. G. Yeomans & Sons.

Bugs do not search for the poison, in order that they may accommodate the orchardist by committing suicide. The one spot which is not sprayed may be the very place where a bud-moth is getting his dinner. On the other hand, there are many fruit-growers who spray with the greatest thoroughness and accuracy, and they are the ones who, in the long run, will get the fruit.

5. *Prepare for next year's work during the winter.*— Secure nozzle and pumps, and fix up the wagons. It is especially important that the wagons be handy. In very low orchards, a low truck may be needed, and in some cases a stone-boat is best; but most orchards will need some kind of a high rig to enable the operator to reach the tops of the trees. Fig. 133 is a rig used by T. G. Yeomans & Sons, Walworth, N. Y. The tank holds 300 gallons. The pump



134.— Outfit of A. H. Dutton, Youngstown.

is placed on the front of the rig (in the seat-rack), and one man drives and pumps. The horses are stopped at every tree. Two leads of hose are used, and two men stand on the rear platform and direct the nozzle. These men have ample space, and the railing gives them security. Until this year a boy has been employed to agitate the liquid with a large hoe. These three men and the boy cost $5.50 per day, and they can spray thoroughly about five acres of full-grown apple trees in a day. This year, an automatic agitator has been employed in place of the boy, with good results.

Another good rig is that shown in Fig. 134, used by A. H. Dutton, Youngstown, N. Y. Many other efficient spraying outfits are in use in this State, but these two will serve to illustrate the kind of work which is needed to be done. The greater number of fruit-growers use an ordinary wagon, with box or rack, and a single 50-gallon barrel; but if one has much spraying to do, it is generally economy to use a larger tank, especially if water has to be hauled some distance; and more thorough work can be done in old orchards if the operator is elevated above the barrel. The use of long pieces of half-inch gas-pipe with the nozzle attached to the end is advisable when one is working in the tops of the trees, but they are apt to be a nuisance if one works from the ground. They are awkward if more than ten feet long. We generally prefer to use a bamboo fishing-pole, and secure the hose to it near its upper end, letting the lower part of the pole remain free. Most operators have insufficient hose. For work in old orchards, the run should be at least 15 feet long.

6. *Prepare stock solutions for the Bordeaux mixture, rather than to make each batch in the quantities called for by the formula.* — The sulphate of copper may be put into solution and kept in this condition indefinitely, ready for use. A simple method is to dissolve 40 or 50 pounds of the sulphate in as many gallons of water, pulverizing the material and hanging it in a coffee-sack in the top of the barrel. A gallon of water, therefore, means a pound of sulphate. The lime may also be slaked and kept in readiness for use. Slake it into the creamy condition familiar to masons, cover lightly with water, and then close the box or vessel to prevent the water from evaporating. When making the Bordeaux mixture, pour the requisite quantity of the stock solution of sulphate of copper into the barrel, and then dilute with four or five times the

quantity of water. Now add the lime, and then add enough water to satisfy the formula. If the ferrocyanide test is used, place a spoonful of the mixture in a saucer or plate, and add a drop of the test solution. If a red color appears, the mixture needs more lime. If the test solution is added directly to a tank or barrel of the mixture, the color reaction is apt to be lost in the mass. An excess of lime ensures the safety of the mixture.

7. *The farmer should know what he wants to kill before he begins to spray.*— It is common to find a man who is going at spraying with enthusiasm, but who can not explain a single definite object which he has in view. He simply knows upon general principles that spraying is useful. To such a man, spraying is spraying, whether he uses Paris green or Bordeaux or both or neither one; and his results are about equal to his knowledge. There is no longer excuse for such ignorance, for all the leading insects and fungi have received more or less exact treatment in the publications of the experiment stations. The state of knowledge is far in advance of the state of practice.

I find many fruit-growers who need such elementary instruction as this:

The arsenites (Paris green and London purple) are used to kill all larvæ or worms, and all those insects which chew the leaves or shoots; such as the codlin-moth, bud-moth, canker-worm, potato-beetle, tent-caterpillar, and the like. Kerosene emulsion is used for scale-insects and plant-lice. Bordeaux mixture and ammonical carbonate of copper, are used to prevent the attacks of fungous parasites; as apple-scab, leaf-blight of the pear, quince and plum, potato blight, and such like.

The times and seasons of spraying depend entirely upon the enemies which it is desired to reach, and upon the weather.

8. *When to spray.*— The grower himself must decide when and how often to spray, because he should know what enemies he desires to reach. If he has the bud-moth, he should spray with the first swelling of the buds, and if he has the plum-scale he should spray in the winter. But leaving the special insects aside, it is safe to say that for the two staple enemies — the apple-scab and the codlin-moth — at least two sprayings should be given. I am not yet convinced that spraying when the tree is dormant has any appreciable effect in destroying the apple-scab fungus. As a general statement I should say, spray twice upon apples and pears, once just as the

fruit buds break open, but before the flowers expand (see illustration on page 567), and again just as the last blossoms fall. In both cases I should use a combination of Bordeaux mixture and Paris green. The first spraying is for the scab fungus in particular, and for this the Bordeaux is used; but the Paris green will most likely be of service in destroying various leaf-eating insects. The second spraying is for the codlin-moth in particular, and for this the Paris green is used; but the Bordeaux mixture will still be needed for the apple scab and other fungi. Whether or not it is necessary to spray again will depend largely upon the season. The operator must watch matters closely, and spray when he needs to do so or when he is in doubt. Two sprayings are sufficient for the codlin-moth, and three are generally sufficient for the apple-scab. These two sprayings which I have recommended constitute the insurance which has already been mentioned; thereafter, the grower will be able to see more definitely just what is needed. At any time when the tree is in growth, Paris green or London purple should be used with lime, or, better, with Bordeaux mixture, to prevent injury to the foliage. One pound of Paris green to 200 gallons of water is the most serviceable general formula for that material; and to this a pound or two of lime may be added.

9. *How can one tell if soluble arsenic is present in Paris green?* It is the soluble arsenic which burns the foliage. This is always present in London purple, but good Paris green should have little of it. Farmers are always asking how they can determine if Paris green contains soluble arsenic. This may be determined by the use of the sulphur test. This test consists in adding sulphuret of hydrogen to a solution of the poison, when, if arsenic is present, a yellow precipitate will be thrown down.

In a bottle holding five or six ounces, place a quarter of a teaspoonful of Paris green. Add water until the bottle is nearly full, shake well, and then allow the material to settle. The clear liquid which remains on top will contain what soluble arsenic may be present. Carefully turn off this clear liquid into a long slender bottle or test tube, add two or three drops of muriatic or sulphuric acid, then add a tablespoonful or more of the solution of sulphuret of hydrogen. If any arsenic is present in the clear liquid, a yellow discoloration will at once appear, and if the liquid is allowed to stand for a few minutes, patches or grains of a sand-like material will settle to the bottom. This yellow precipitate is sulphide of arsenic. If very little soluble arsenic is present, the sulphuret solution should be warm when used, for the reaction is then more delicate. The sulphuret is easily made by anyone who has had even an elementary instruction in chemistry, by adding sulphuric acid to iron pyrites.

This sulphuretted hydrogen is not a commercial preparation, but it is present in all sulphur mineral water, and the water may give the test that I have described. One can always make sure of the presence of this material, for its odor is strong and offensive. It is the odor of spoiled eggs. If mineral water is used, it should be strong and fresh and about equal in quantity to the arsenic solution; and even then only a faint amber discoloration may appear, because of the small amount of sulphur in the water.

This test of arsenic determines only the fact that soluble arsenic is or is not present. It does not determine how much soluble arsenic there may be; although the greater or less amount of the yellow color on precipitation will afford a comparative idea of the amount present in any two or more samples.

I have already advised the use of lime with Paris green or London purple for the purpose of taking up the soluble arsenic, by the formation of arsenite of lime. If this is done, or if the Bordeaux mixture is used with the arsenites, it will not matter if the poison contain soluble arsenic.

10. *How can one determine if Paris green is pure?* — It sometimes happens that material which is obtained as Paris green contains no arsenic. We once procured such a sample, which proved to be chrome green. If the material is pure Paris green it will quickly and completely dissolve in common strong ammonia, giving a beautiful, rich, dark blue, clear liquid, whilst any of the compounds which would ordinarily be substituted for Paris green on account of their color and texture, will not behave in this manner in ammonia. Any insoluble residue is impurity. Chrome green will not dissolve in ammonia.

11. *What becomes of the arsenic when it falls upon the soil?* — With the action of the rain and the falling of the leaves most of the arsenic which is applied to trees finally reaches the soil. What then becomes of it? If lime has been used with the spray the arsenic will be insoluble when it falls upon the soil. It is possible that the organic acids in the soil, and also carbonic acid, may dissolve some of the arsenic, but it would be almost surely made immediately insoluble again by combination with lime or other soil

constituents. If soluble arsenic is placed on the soil it probably almost immediately goes into insoluble combinations, and remains where it was placed unless slightly washed down by mere mechanical means. Now some plants appear to have the power to take up every minute quantities of arsenic and still thrive — probably so minute that the nicest chemical test can scarcely discover it* — but any appreciable quantity of soluble arsenic in the soil quickly destroys the roots. If, therefore, the grass and other plants under sprayed trees continue to live, there need be no fear that the arsenic will injure the soil.

We have made some study of the movement of arsenic in the soil during the past summer, and the results are here given. The chemical work was done by G. W. Cavanaugh, assistant chemist to the Experiment Station, the determination of arsenic being made by Marsh's test, which is known to chemists as one of the most delicate means of detecting the poison.

Experiment I.

May 26th, 1895. Two ounces Paris green and four ounces lime were mixed in one quart of water, and the liquid was poured into a little hollow as large as a saucer in the bottom of a shallow furrow in firm but rather sterile moist, sandy land. A sample of the same Paris green was taken to the chemist and found to be of normal strength, and to contain a little arsenic soluble in cold creek water. On the night of the 26th nearly an inch (.87 in.) of rain fell, and on the night of the 28th I poured a quart of creek water on the area, covering it three inches deep. Samples of the underlying soil were taken for analysis as follows:

A. May 30th. Sample taken two inches below the surface of the soil (that is, two inches underneath the stratum of poison). Three most careful analyses were made and not a trace of arsenic was found.

B. June 6th. Sample taken two inches down, as before. In the meantime a slight rain had fallen (.09 in.) and the weather was very hot. Not a trace of arsenic was found.

On October 7th, 1895, the soil was examined again. It had now received a total rainfall of about twelve and a half inches (12.35 in.).

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* The student should consult Jäger's "*Uber die Wirkungen des Arseniks auf Pflanzen.*"

The soil was very firmly compacted, and was light reddish yellow, denoting the absence of vegetable matter. Plants were growing profusely all about the spot, sending their roots close about the poisoned area. Upon making a section of the soil various holes were found, left by the decay of roots, and in these channels the Paris green could be plainly seen at a depth of two or three inches. Aside from this, there was no visible evidence of the Paris green in the soil, but the entire original application still lay intact just under the surface, having been slightly covered with soil by the rains of summer.

C. Sample taken October 7th, 3 in. down, and found to contain the merest trace of arsenic, not enough to make a quantitative estimate possible.

D. Another sample at 3 in., which also showed the merest trace of arsenic.

E. Sample at 5 in. showed considerable arsenic, more than at 3 in. (C). On searching for the cause of this the sample was found to have the remains of a rootlet about the size of a knitting needle running down through it. It was evident that the arsenic had passed down this channel. Consequently another sample was taken:

F. Five in. deep, in solid soil. No trace of arsenic under the most searching test.

G. Seven in. deep. No arsenic.

Experiment II.

On the 5th of June, 1895, 2 oz. of Paris green (from the same stock as that used in Exp. I.), without lime, was placed on an area as large as the two palms, on a low, black, moist soil which had been deeply spaded the fall before. The soil was loosened up an inch deep with the trowel and then lightly compressed with the hand; and on this surface the poison was placed, and then covered with a half inch of earth. This land was moist all summer long, and when the first examination was made, Oct. 5, the area had received eleven and a half (11.39) inches of rain. As in the first experiment, plants sprung up close about the spot and grew lustily. The examination in October showed that the under soil tended to run together in blocks, so that it was brittle and seamy; and angle-worms had worked in it. The basis of the soil was clay, which had become dark-colored by the accumulation of humus.

When the following samples were taken, Oct. 5, the old application of Paris green was still intact just under the surface, apparently as abundant as when first applied, but none of it could be traced in the soil by the eye.

A. Soil taken at one-half in. below the layer of poison. Much arsenic present.

B. Sample 1 in. down. Much arsenic present.

C. Two in. down. Some arsenic found.

D. Five in. A very little arsenic was present.

E. Seven in. down. A trace of arsenic found, yet the poison was even here more abundant than it was at 3 in. in the sand (C in Exp. I.)

F. Eight in. down. No arsenic.

The questions now occur how the arsenic went down in the soil, and why it went deeper in the clay loam than in the sand. We must first determine if the arsenic went into solution and was carried down by the natural drainage. It will be remembered that at ½ in. under the surface in the loose clay loam (A, Exp. II.), plenty of arsenic was found. A sample of this soil was thoroughly digested in hot water, and the water carefully tested for arsenic, but not a trace of it was found. This shows that the arsenic was in an insoluble condition, and that it was probably carried into the soil simply by the mechanical action of the rain. There are various other considerations which also support this view. We have seen that it evidently followed the remains of the root in one instance (E. F. Exp. I.). It went down farther in the clay loam because that soil was seamy and burrowed by worms. The sand is a better filter. Again, if the arsenic had been dissolved in the soil water, it would have gone much farther down, for the eleven inches of rainfall on the moist soil of plot II. (there was no surface drainage possible) must have gone many more inches into the soil, for there were some heavy rains; and a similar remark will apply to plot I. Again, if the arsenic were in solution in the soil, it would pass laterally, as well as downwards, with the movement of soil water, and the plants which grew on the very edges of the plots would have suffered.

The gist of the whole matter then, if we may generalize from these tests, is that the arsenites do not leach from the soil. They remain where they fall, the same as sand does, and are carried down only when there are crevices or other openings in the soil, and they then go down as insoluble compounds, and to a slight extent, by the mere mechanical action of the water. It is really remarkable that the sand, in Exp. I., was such a perfect filter as to hold the great quantity of arsenic above a depth of three inches for over four months. If the soil in either experiment had been a homogeneous subsoil, where the sun could not have cracked or checked it, it is fair to conclude that no arsenic could have penetrated it.

II. THE CANKER–WORM.

The canker-worm is one of the most dreaded scourges in western New York. It is an old offender, and yet its appearance in an orchard or on shade trees still awakens as much terror as would the introduction of some strange and omnivorous pest from another country. The reason why the canker-worm always commands this wholesome respect is because it is a voracious feeder. It multiplies with astonishing rapidity when it has once established itself upon a plantation. Its work is so apparent that the most careless person is arrested by it. The presence of the canker-worm is an evidence of neglect, and it is at the same time a most efficient reminder of that fact to the owner of the plantation. It is a leaf-eating insect and should, therefore, be dispatched with Paris green. In fact, it is the very insect upon which the first efficient experiments were made with that insecticide and from which the recent development of the spraying of trees has come. An insect which has done so much good as to have demonstrated the means of its own destruction and to have given the hint for the annihilation of all its allies, should be held in pleasant remembrance.

Yet, the orchardists complain that they cannot kill the canker-worm with poisons. Some persons even declare that its keenest delight is to feed on Paris green. It is well known, however, that the insect is as susceptible to poisons as other leaf-feeding worms, and there are experiments enough on record to show that spraying is capable of wiping out the pest. It is evident, therefore, that the reason why so many people fail to kill it by spraying is because they do not perform the work thoroughly and in season; and then, it is a fact that the worm very often becomes thoroughly established and settled in an orchard before the orchardist ever notices it, or, at least, before he decides to do anything about it. It is probably impossible to rid an orchard of the worm in a single season if the pest is so numerous as to devour all the leaves. It should have been destroyed two or three years before such a state of affairs is possible.

On the 4th of last May, the Farmers' and Fruit Growers' Association of Orleans County, asked us to make a test, and the society set apart the orchard of F. D. Scott, near Medina, for the purpose. I had visited this orchard on the 25th of June, 1894, just after the worms had left it, and found many of the trees wholly bare of leaves. It is a full grown orchard of various varieties, on rather low ground, and comprising 240 trees set about 30 feet apart each way. It is a neglected orchard, and the worms have no doubt been working in it for some years, although they were not observed until the serious outbreak of last year advertised their presence. On the 4th of May, last spring, when the plantation was put in our hands for experiment, there were no indications of worms in the orchard. On the 9th of May, I visited the orchard again and found myriads of worms ranging from an eighth-inch to a fourth-inch in length. They had already done considerable damage to the little leaves, and it was apparent that we were already too late to save the orchard from serious injury. The flower buds had mostly broken open, but the flowers had not yet expanded. The condition of the buds at this time was a little more forward than the cluster shown in the illustration on page 567. The leaves were about an inch long.

On the 10th of May the spraying was begun. Since the day before, the insects seemed to have increased with amazing rapidity, and when the limbs were rapped or jarred several excited worms would spin down from every leaf. It looked like a hopeless task to conquer them. The most infested part of the orchard was divided into six plots, and these were treated as follows:

I. One pound Paris green and 2 pounds of lime to 200 gallons of water.

II. One pound Paris green, 2 pounds lime, 144 gallons water.

III. One-half pound Paris green, ½ pound London purple, 2 pounds lime, 225 gallons water.

IV. One pound London purple, 2 pounds lime, 96 gallons water.

V. One pound acetate of lead, 5⅓ ounces arsenate of soda, 200 gallons water. (The arsenate of lead mixture used successfully against the gipsy moth in Massachusetts.)

VI. One pound acetate of lead, 5⅓ ounces arsenate of soda, 100 gallons water.

The spraying began at 9 o'clock in the morning. We used Vermorel nozzles on a Y, and the liquid was applied until the trees were thoroughly wet and began to drip. My diary says that at 2 o'clock that afternoon "about one worm in every six is dead in Plot I."

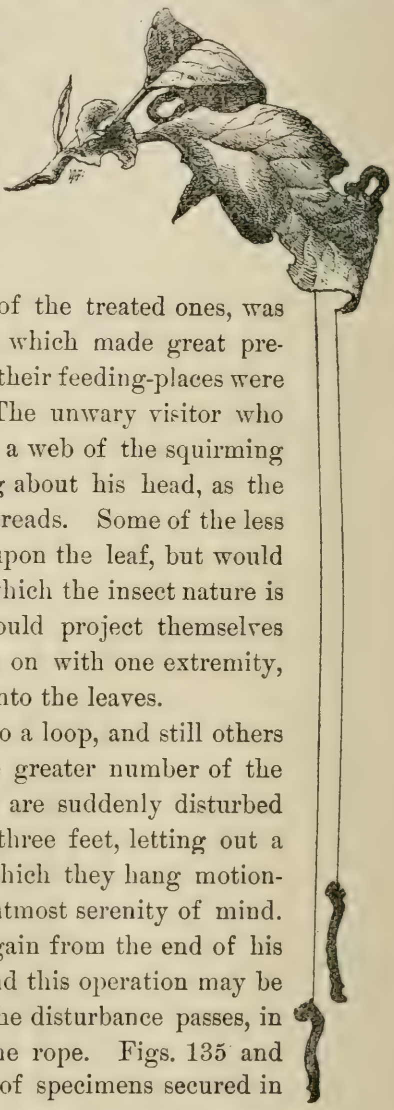
Saturday, May 11. "Discouraged; even in Plot I. nine-tenths of the worms are in good health."

Monday, May 13. "Feeling better. Nine-tenths of the worms on Plots I. and II. are dead. Plot III. gives fairly good results, over half the worms being dead. Plot IV. about half the worms dead. Plots V. and VI. show few dead worms, although the results are passably good on the limbs which were very heavily sprayed."

On the 13th, most of the flowers were open, and the largest worms had reached the length of an inch. At this time, every green thing on the untreated trees, and on many of the treated ones, was alive with the industrious worms, which made great pretense of being offended whenever their feeding-places were in the least manner disturbed. The unwary visitor who jarred a limb would instantly find a web of the squirming and grotesque creatures swimming about his head, as the larvæ dropped on their gossamer threads. Some of the less active individuals would remain upon the leaf, but would assume every manner of pose of which the insect nature is capable. Some of the worms would project themselves rigidly into the air whilst hanging on with one extremity, like so many shingle-nails driven into the leaves.

Others hunch up their backs into a loop, and still others lie motionless upon the leaf. The greater number of the worms let go, however, when they are suddenly disturbed and drop instantly from one to three feet, letting out a thread as they go, at the end of which they hang motionless for a time, as if enjoying the utmost serenity of mind. Sometimes an individual lets go again from the end of his thread and drops another notch; and this operation may be repeated two or three times. If the disturbance passes, in a few minutes the worm ascends the rope. Figs. 135 and 136 are characteristic illustrations of specimens secured in Scott's orchard.

Although the Paris green was plainly killing the worms, it was soon apparent that more than ordinary measures



135.—The Canker-worm.

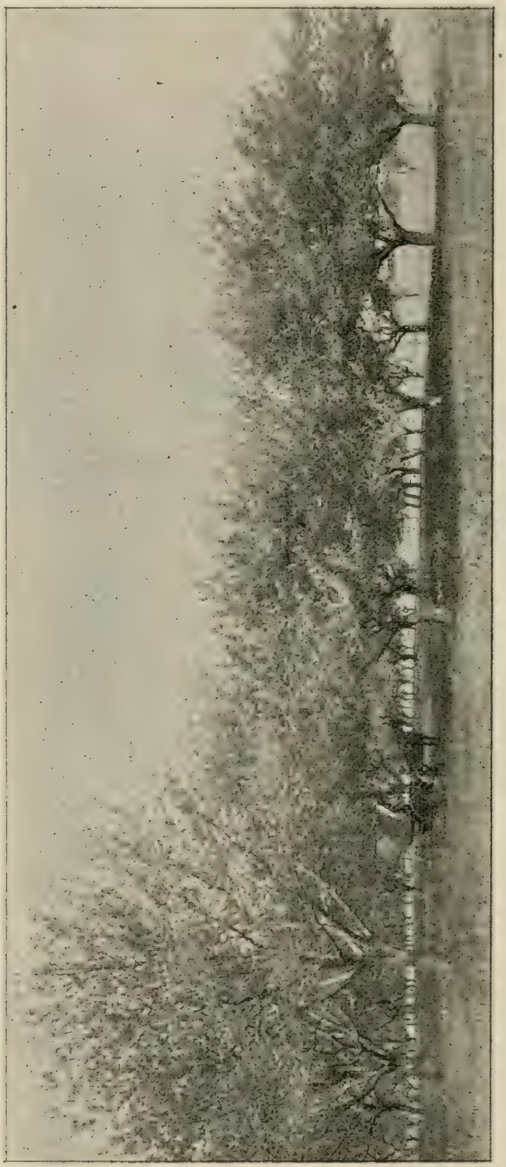
must be taken to dispatch the scourge. Accordingly, we secured an outfit of McGowan nozzles, which would do double the work of the Vermorels, and sent our best man, Peter C. Toner, into the orchard to remain until he killed the worms. He began work on the morning of May 13th. It was evident at this time that the best results had been obtained from the Paris green, and the dilute mixture (1 to 200, in Plot I.) had been as efficient as the stronger one. Accordingly, we gave up all experimenting with mixtures, and gave our attention wholly to the worms, using 1 pound of Paris green to 200 gallons of water, adding a little lime to prevent injury to the foliage. Fig. 137 shows a portion of Mr. Scott's orchard. This second spraying was done with great thoroughness, and I append diaries of it in order that the reader may calculate the cost of the treatment, if he desires. The gang consisted of our man Toner, and a helper, with a one-horse wagon carrying a 50-gallon barrel. It was necessary to go from ten to forty rods for water.

136.—A full crop. Natural size (Larvæ about ¾ grown).

May 13. Began work at 10 o'clock; used 5 barrels of mixture; quit at 5:30. Hauled water about 40 rods.

May 14. Rain and snow.

May 15. Began work at 10 o'clock; used 10 barrels of mixture. From now on, the water was procured near the orchard. Went over the trees sprayed on the 13th, because of the rain.



137.— The orchard which was sprayed for Canker-worm.

May 16. Used 9 barrels; pump had to be repaired, causing some loss of time.

May 17. Finished the orchard, using 11 barrels of mixture; quit at 5 o'clock.

Certain Roxbury Russet trees were the worst affected. In fact, the worms were so numerous that it seemed well nigh an impossibility to annihilate them. These trees, therefore, received particular attention. Toner's diary is as follows:

May 13. "Sprayed Russets in the afternoon, and they were alive with worms."

May 15. "Examined the Russet trees and found the worms lively and in good health, but think the failure of the spray was due to the rain of yesterday and the night before. Sprayed them again this morning. At 5 o'clock in the afternoon the worms were as lively as ever."

May 16. "Found worms dying on the Russet trees. One of the trees which was the worst on yesterday morning had scarcely a worm on this evening. Believe they can be killed out with the Paris green if the spraying is well done."

May 17. Found a few worms on the Russet trees. Sprayed them again in the morning. At night there were scarcely any left."

Not counting the first day's work, there were used 1,500 gallons of mixture. The orchard has 240 trees, making a trifle over 6 gallons of liquid to the tree.

I visited the orchard on the 18th and found the worms nearly all dead, and I was much pleased with the result. Great damage had been done to the foliage, however, and it was evident that the injury in a badly infested orchard can not be averted in a single year. On the 22d I was in the orchard again, and my diary reads as follows: "Rarely a worm to be found in good health. Most trees seem to be entirely free, the Russets almost completely so; now and then a limb has a few worms, but they are mostly small and evidently hatched out since the spraying was done. Yet these Russets look brown and scorched from the work of the worms." The photograph on page 586 was taken at this time.

On June 1st my associate, Mr. Lodeman, visited the orchard and reported a good many worms, although they were not in serious numbers. Subsequently the worms became more numerous, although they never did noticeable damage to the orchard after we left it. These later worms had evidently hatched out late in the season, but it is probable that most of them were killed by the poison still remaining on the trees. We had demonstrated that a thorough treatment with Paris green is capable of destroying the canker-worm, and the subsequent care of the orchard was left to the owner. The orchard should have been sprayed again. I expect that if the orchard now receives two thorough sprayings each spring, as advised for the codlin-moth, the canker-worms will disappear, but if the orchard is neglected the worms will likely be as bad as ever in a year or two. I visited the orchard again on the first of August, and found that many of the trees which had been most seriously involved were making a fairly good growth, with large and strong leaves, although the ragged, early foliage was still upon the trees. Last year many of the trees lost their foliage completely and most of them made no growth.

There are two species of canker-worms, the fall and the spring species. The one which is now common in western New York seems to be the spring canker-worm (*Paleacrita vernata*, formerly known as *Anisopteryx vernata*). The worms feed greedily for three or four weeks and then go into the ground where they enter the pupa state and remain until the following spring. Occasionally the moths appear in late fall or during warm spells in winter, but they usually emerge in early spring, when the buds begin to swell. The thin-winged, white male moth is shown full size in Fig. 138, which figure is made from nature with great care. The female moth (Fig. 139) is wingless, and crawls up the tree, laying her eggs under shreds of bark or in the expanding buds. The eggs hatch unevenly or else the period of egg-laying is long, for the worms continued to appear in Mr. Scott's orchard this year for a period of two weeks or more. The reader is familiar with the bandages of tar, printer's ink, cotton, and other materials placed about the trees to prevent the female moth from climbing up. These devices are very serviceable for large shade trees, but if the fruit grower keeps his orchard in cultivation and sprays honestly once or twice each year for codlin-moth and other insects, he need not fear the canker-worm.

138.—Male moth of canker-worm. Full size.

139.—Female moth. Full size.

SUMMARY.

1. Spraying is only one of several means or operations which the pomologist must master if he aspires to the greatest and most uniform success. Other fundamentally important requisites are tilling, fertilizing and pruning.

2. Spraying is not necessary to successful results every year, but inasmuch as the farmer cannot foretell the need of the operation, he should spray as a matter of insurance.

3. Spraying is almost sure to be of some benefit every year, particularly upon apple, pear, plum and quince trees.

4. Spraying is of little consequence unless carefully and honestly done. The spray must actually reach every point which it is intended to protect.

5. Prepare for the year's campaign during the previous winter, by reading the latest teachings, and by completing pumps and appliances. Give particular attention to a convenient wagon outfit (Figs. 133, 134).

6. The Bordeaux mixture need not be made up at each using in the exact numbers of the formula. The copper sulphate may be permanently dissolved in water and the lime may be slaked. When the mixture is prepared, the stock solution of vitriol is diluted, the lime added, and the tank filled to the required amount.

7. Spraying is well nigh futile unless the operator understands precisely what he sprays for.

8. The time to spray is when the operation is needed to protect the plant. This will vary, therefore, with every season and every different pest. In general, we advise spraying apples and pears twice, first, when the fruit-buds open, but before the flowers expand, and again when the blossoms fall.

9. The presence of soluble arsenic in Paris green may be determined by a test with sulphuret of hydrogen.

10. Pure Paris green dissolves completely in ammonia, giving a rich deep blue liquid.

11. The arsenic which falls upon the soil seems to become or to remain in an insoluble condition, and passes downwards, if at all, to a very little distance and then only by the mechanical action of water in carrying it through spaces in the soil.

12. The canker-worm can be killed by honest spraying with Paris green, 1 part to 200 gallons of water.

L. H. BAILEY.

BULLETIN 102—October, 1895.

Cornell University Agricultural Experiment Station.
HORTICULTURAL DIVISION.

GENERAL OBSERVATIONS
RESPECTING THE
CARE OF FRUIT TREES,
WITH SOME REFLECTIONS UPON WEEDS.

> The father of humankind himself ordains
> The husbandman should tread no path of flowers,
> But waken the sleeping land by sleepless pains.—
> So pricketh he these indolent hearts of ours,
> Lest his realms be in hopeless torpor held.
> * * * * * *
>
> And all these things he did,
> That man himself, by pondering, might divine
> All mysteries, and, in due time, conceive
> The varying arts whereby we have leave to live.
> — *Virgil.*

By L. H. Bailey.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1895.

84. The Recent Apple Failures in Western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. On the Effect of Feeding Fat to Cows.
93. The Cigar-Case Bearer.
94. Damping Off.
95. Winter Muskmelons.
96. Forcing-House Miscellanies.
97. Entomogenous Fungi.
98. Cherries.
99. Blackberries.
100. Evaporated Raspberries in Western New York.
101. The Spraying of Trees; with remarks on The Canker-Worm.
102. General Observations Respecting the Care of Fruit Trees; Weeds.

Cornell University,
Ithaca, *October* 12, 1895.

The Honorable Commissioner of Agriculture, Albany:

Sir: The one subject which is uppermost in the minds of the fruit-growers of western New York is the cause of the failures of the apple orchards to bear. There are two methods of investigating the subject. One method aims to collect data from the orchards themselves, from every condition and location in which they are grown, and to reflect upon the mass of observation and experience which is thus acquired. This method is essentially one of generalization, and it is safe only when the student brings to his aid an extended series of facts, and when he considers them with judicial deliberation. Its chief fault is the danger that the student may overlook certain minor facts, and that his generalizations may be applied to too many diverse conditions. Yet, in most subjects touching the general economy of agriculture, such as the management of land and crops and business, it is a most promising method of research.

The other method consists of a minute examination of a few facts or a small field, and the drawing of such conclusions from them as seem to apply to broader areas. It is essentially a specialization, and it is safe only when the facts under observation are positively understood, and when applications are made by the student with the greatest caution. Its fundamental details are so exact, and it presents such an array of figures and facts, that it at once enlists the sympathies of the reader and convinces him; therefore, it is generally considered to be the proper type of scientific inquiry. Its chief fault is the danger that conclusions which are undoubtedly true for a narrow field may be held to be equally true for a wide one.

When the Nixon bill was passed a year and a half ago, and we were asked to study the horticulture of western New York, it was conceived that an inquiry into the lessening productiveness of orchards was more needed than any other single investigation. From that time until now the subject has been constantly under consideration, and two bulletins (72 and 84) have already been devoted to some aspects of it. The question has been divided into two parts—one, a study of the general conditions of our orcharding, the summary conclusions of which are presented in this paper; and the other, a study of the exact behavior of individual trees, a subject which was taken up by Professor Roberts and the summary of which is given in Bulletin 103. These two bulletins complement each other, therefore, and they represent the latest and best knowledge which we have been able to apply to the perplexed subject of orchard management, particularly to that part of the subject which is associated with the declining productiveness in recent years. In the preparation of the present bulletin, the writer has had before him the results of observations made in many hundred orchards in western New York during two seasons; and in Professor Roberts' account there is published a more complete chemical history of fruit trees than has ever before been made in this country, and his bulletin presents the strongest arguments yet advanced for the better feeding and care of orchard trees.

The two investigations have reached essentially the same conclusions—that orchards need more thorough tilling and fertilizing than they commonly receive. A most gratifying feature of the inquiries is the fact that both have arrived independently, and from very different points of view, at exactly the same conclusion respecting the causes of the singular circumstance that land which is cropped with nursery trees is generally incapable of soon raising another crop of such trees. This is not due to the depletion of the elements of plant food in the soil, but to the modification of the texture of the soil consequent upon methods of handling the crop and upon the fact that both roots and tops of the plants are removed bodily, leaving practically no vegetable matter to enliven the land. A number of experiments are now in hand in nursery lands which may be expected to throw additional light upon some of these problems. These two bulletins are submitted to be published and distributed under Chapter 230 of the Laws of 1895.

L. H. BAILEY.

OPINIONS OF LEADING WRITERS TOUCHING THE CULTIVATION OF ORCHARDS.

The looser the ground is kept for the first, and indeed for several succeeding years, the more certain and more vigorous will be the growth of the orchard—in the luxuriance and colour of the foliage of contiguous plantations, I have found every stage of cultivation strongly marked: those orchards which have been two years under cultivation, exhibit a striking superiority over those which have been but one year under the plough; while these, in turn, surpass the fields in clover or in grain, both in the quantity and size of the fruit.—*William Coxe*, *A View of the Cultivation of Fruit trees*, 1817, (*The first American fruit-book.*)

We next proceed to cultivate the soil beneath, and between the trees, until they arrive at their complete size, as the quality, excellence and maturity of the fruit will, in a great measure, depend upon its proper culture. * * * In fact, it has been ascertained by experience and observation, that apples, pears, peaches, etc., attain to their highest perfection only when the soil about the roots is kept open, and frequently manured.—*James Thacher*, *The American Orchardist*, 1*st Edition*, 1822.

Fallow crops are the best for orchards,—potatoes, vines, buckwheat, roots, Indian corn, and the like. * * * If we desire our trees to continue in a healthy bearing state, we should, therefore, manure them as regularly as any other crop, and they will amply repay the expense.—*A. J. Downing*, *The Fruits and Fruit Trees of America*, 1*st Edition*, 1845.

Among the hoed crops which are best suited to young trees, are potatoes, ruta bagas, beets, carrots, beans, and all low hoed crops.— * * * All sown crops are to be avoided, and grass is still worse. Meadows are ruinous.—*John J. Thomas*, *The Fruit Culturist*, *Fourth Edition*, 1847.

Grain crops should never be planted among trees, as they deprive them of air to a very injurious extent. If no root crops are cultivated, the ground should be kept clean and mellow with the one horse plough and cultivator. * * Every third or fourth year the trees should receive a dressing of well-decomposed manure or compost.— *Patrick Barry, The Fruit Garden*, 1*st Edition*, 1860.

If the ground, which has been appropriated to the orchard, be also occupied as farming land, as is usually done for a few years after planting, while the trees are small, it should be exclusively devoted to hoed crops; by which is meant those that require constant cultivation and stirring of the soil.—*John A. Warder, Apples*, 1867.

The entire soil where an orchard is growing should be either mulched, or cultivated, or hoed over so frequently during the growing season, that all vegetation will be completely subdued.—*S. E. Todd, The Apple Culturist*, 1871.

I. Observations on the Care of Fruit-Trees.

In considering the subject of the proper care to be given to fruit-trees, one is struck with the fact that all kinds of fruits are sufficiently productive in western New York, save only the apple; and a moment's reflection brings to mind the fact that the apple, alone, is the fruit which is commonly raised in sod and which everywhere receives the least attention. The presumption is at once raised, therefore, that this sod and neglect are in some vital way associated with the declining productiveness of apple-trees. In order to put ourselves right upon the question we must first of all ascertain, if we can, why the apple is of all fruits the most neglected.

My older readers will recall the fact that until recent years the effort of the farmer has been directed to the growing of hay, grain and stock. Previous to this generation the growing of fruit has been a matter of secondary or even incidental importance. A bit of rocky or waste land, or an odd corner about the buildings, was generally given over to the apple orchard, and if the trees received any attention whatever it was after all other demands of the farm had been satisfied. All this was particularly true of the farming previous to the second third of this century, and the apple and standard pear orchards of the country still record the old method. It has required at least a generation of men in which to thoroughly establish any new agricultural system, and the time is not yet fully arrived for the passing out of the old orchards and the coming in of the new. In other fruits than apples and standard pears the generations of trees are comparatively short lived and those fruits sooner feel the effects of new agricultural teachings. Orchards of plums, dwarf pears, apricots, cherries and quinces have mostly come into existence along with the transition movement from the old to the new farming, and they have been planted seriously, with the expectation of profit, the same as the grain crops have. Peaches had passed out in most parts of the east, and they are now coming in again, with the new agriculture. At the present time men buy farms for the sole purpose of raising fruit, a venture which would have been a novelty fifty years ago; but the habit of imitation is so strong that the apple planter patterns after the old orchards which were grown under another and now a declining system of agriculture, and many of which are still standing on the old farms of New York State.

But there is still another reason for the neglect of the apple orchard. Until fifty or sixty years ago the chief end of the apple was the cider barrel. All the old writings enforce this idea. John Taylor's famous "Arator," printed in Virginia early in this century, declares that "the apple will furnish some food for hogs, a luxury for his family in winter, and a healthy liquor for himself and his laborers all the year." He says that "good cider would be a national saving of wealth, by expelling foreign liquor, and of life, by expelling the use of ardent spirits." Coxe's "Cultivation of Fruit Trees," in 1817, devotes nine chapters to cider and its products. The whole temper of the country was to make cider of the apple. There is a record that one settlement near Boston, of about forty families, made nearly three thousand barrels of cider in 1721; and another New England town of 200 families made "near ten thousand barrels." Now, any apple will make cider; and the presence of worms and apple-scab, and all the other accessories, may be supposed to add to the merits of the product. It was not necessary to care for orchards which were to grow cider, and the habit of neglecting them has become so indelibly impressed upon the public mind that all the teachings of the last generation have not been able to erase it. The sod orchard is a survival.

Now, I am not urging that the farmer shall put his apple orchard under clean tillage. I am simply trying to press home the fact that apple trees must receive thought and care if the owner is to expect much return from them. If tillage and timely effort are good for corn, and peach trees, and blackberries, they ought also to be good for apple trees. I asked a farmer not long ago what his apple orchard is worth. "It is worth a good deal. A crop of apples is a clean gift." He said more than he knew, and his thought is uppermost in many farmers' minds in this State. If a thing is "a clean gift," no effort has been expended to secure it. It is no merit of the average farmer if now and then he goes into his orchard and finds a crop of apples there; and he should not complain if half the apples are scabby and all of them are wormy. It is a generous soil which gives a crop of hay or grain year after year under a most neglectful treatment, and then occasionally throws in a crop of apples to boot.

My reader may agree with these general remarks, but he insists that we tell him just how to make his apple orchard bear. He wants methods. And this is just what no one can give him. Every farmer should know his own farm better than any one else knows it. He knows the soils, the exposures, his own limitations of help and capital, and all the many interacting factors which make a piece of land a farm. Some one may be able to instruct him in principles, but he must apply them for himself. A principal may need a different application on every farm. Every farmer knows this fact, when he comes to think of it; for there are no two good farmers who perform the same operation in the same way. If a person once knows the underlying reasons for plowing in the fall or in the spring, or deep or shallow, he can soon think it all out for himself just how he ought to plow on his own place.

What will make my orchard bear? Nobody knows. Ask the trees. Study the conditions. Think about the orchard. Try one method here and another there. Try to find out why it does not bear. Perhaps the varieties are not productive ones. Perhaps the flowers do not fertilize. Perhaps the soil is too low or too poor. The orchard may need spraying, or, possibly, even manuring or plowing up, or pruning. Or, oftener, perhaps it needs cutting down and a new one started all over again, with the matter done right from the beginning. It is hard work to break a colt when he is ten years old, and then he never makes a good horse.

It is certain that there is no one cause for the failure of all apple orchards to bear. There are many, perhaps very many causes. The experimenter should be able to discover these causes and to explain them; but just which one is at the bottom of the failure in any particular orchard the owner himself must find out, if he can. And he cannot expect to find out in one day or perhaps in one year. He must revolve the matter in his mind, as he goes and comes, day by day, in rain and shine, and he will finally come to an opinion, unless, unfortunately, he has an opinion before he begins to revolve the matter.

It may help the farmer if I enumerate the chief causes which seem to us to be responsible for most of the failures of orchards. These suggestions are meant to apply with particular force to the apple, although they are true in varying degrees of all other fruits.

1. *The farmer wants to get his fruit without earning it.*—The farmer's frame of mind is likely to be something like this, "How can I secure that crop with the least expenditure of effort?" A more rational attitude is one which asks, "How much labor can I put upon that crop with profit?" In orchard-growing, particularly if the orchard is of apples, there is still much of the old feeling that trees can wait until all other crops of the farm are served. As the orchard is conceived in the mind of the planter, so will the harvest most likely be. A plantation poorly planned, or not planned at all, carries its faults throughout its life. For this reason, I think it impossible to make many of the orchards of the State profitable, even if now given the best of care.

2. *There are frequent mistakes in the choice of land and sites for an orchard.*— There is, in general, accurate practice in western New York in the selection of the proper soil for trees — clay for pears, clay loams for plums and quinces, sands for peaches, and loose loams for apples — but there seems to be less attention given to the choice of the aspect and the "lay of the land." A person who has nearly one hundred acres of unprofitable apple orchard asked me to inspect his place for the purpose of discovering the cause of the unproductiveness of the trees. It required but a glance at the plantation to see that the land was wholly unsuited to apples. It was flat land, with a tenacious and impervious subsoil lying only a foot or two below the surface. In order to carry off the water, the owner had left the dead-furrows open and had plowed a series of open ditches about the borders of the plantation. He supposed that if he carried off the surface water, all the requirements would be satisfied; but the hard subsoil remained intact, and the roots of the trees lay near the surface, so that when I visited the place, in mid-summer, the trees were suffering from drought. The trees had no doubt soon robbed the surface soil of most of its richness and, unable to penetrate the lower levels freely, they were now stunted and unthrifty. The owner had various expedients in mind for the renovation of the orchard, but the very first requisite—a thorough system of tile drains—had not occurred to him. All other treatment will probably be well-nigh useless until these drains are supplied; and even then I doubt if the orchard can ever be made profitable, for such sites are never good orchard lands and the habit

of the trees is now probably too thoroughly established to be easily overcome.

This instance is a type of very many orchards in western New York. There are other apple and pear and plum orchards which stand upon dry and leachy hillsides. Good drainage, thorough tillage and fertilizing are capable of correcting some of these fundamental difficulties of site and soil, but these treatments, to be most effective, must be begun early in the life of the orchard.

3. *Neglect of tillage is the commonest fault of the orchards of western New York.*—Apples and some other fruits, yield so well under neglect that it has come to be a common notion that they do not need tillage. There are many orchards in sod which are profitable, and these have been held to be proof that orchards thrive best in sod. But by far the greater number of orchards in grass, the country over, are unprofitable, and it seems to be a safer generalization to say that these are proofs that fruit trees do not give profitable return in sod. Every orchard is profoundly influenced by the particular soil and other conditions in which it grows, and it is generally impossible to ascribe its behavior directly either to soddiness or sodlessness. But if one contrasts for a moment the known effects of tillage and neglect upon the soil, he will see at once that good judicious cultivation must give the better results in orchards; and there is ample proof of it in all annual crops, and even in most fruits, particularly in grapes, berries, peaches and plums. The latter plants are always thought of as cultivable crops, yet they do not differ from apple trees in any fundamental method of living.

Let us recall some of the effects of tillage upon the soil:

It sets free plant food;
  promotes nitrification;
  supplies air to the soil and roots;
  makes all the soil available, by fining it;
  breaks up the hard-pan;
  makes a reservoir for water;
  warms and dries the soil;
  saves the rain, by taking it into the soil;
  prevents evaporation, or conserves moisture;
  sends the roots of trees downwards, and makes the moisture and fertility of the subsoil available.

All these benefits must be as useful to the apple tree as they are to strawberries or currants. Yet, tillage may be a positive damage to the orchard, if injudiciously done. Just what is judicious tillage must be determined for every farm and every season; in fact, just here is the point where the greatest skill is required in farming. A man must know the underlying principles of the operation before he can practice it successfully. Yet two or three points of advice may be noted in passing:

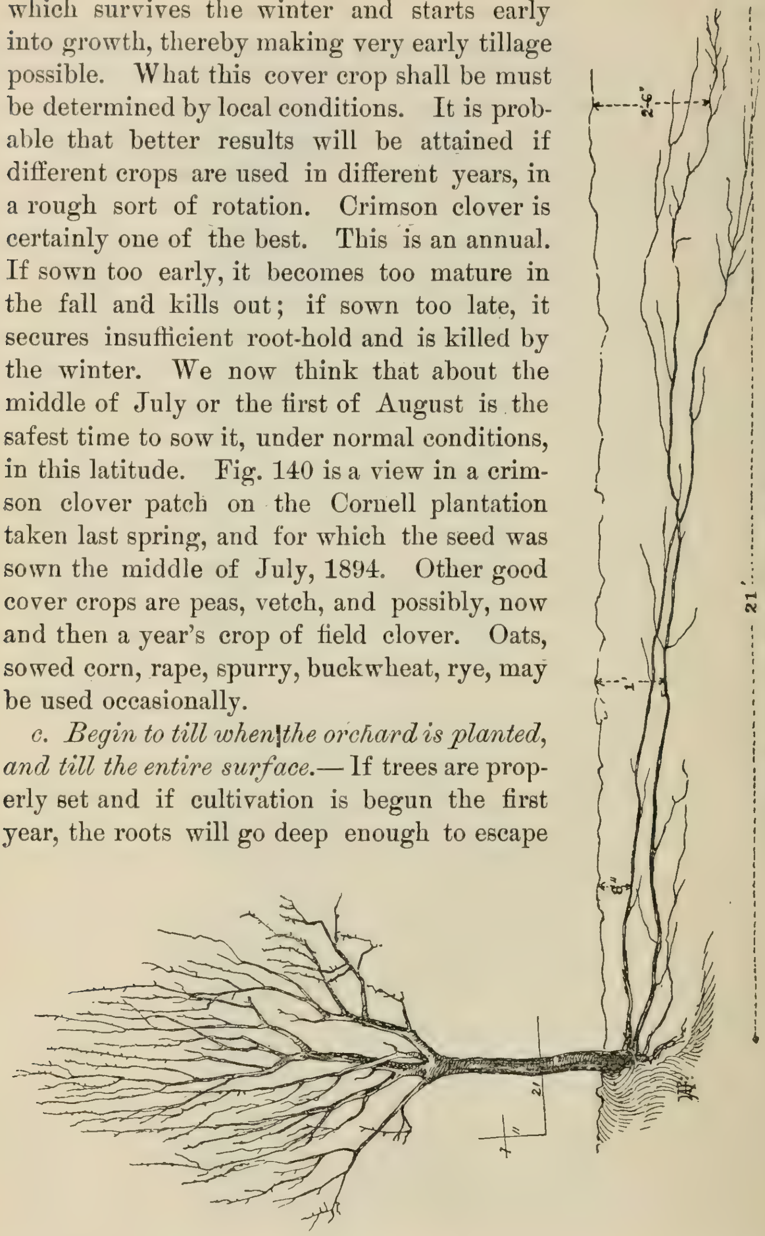
a. Tillage should be begun early in the season, in orchards.— Trees complete most of their growth by the first of July. Early tillage saves the moisture which has accumulated during the winter and the spring; it is capable of putting the soil in fine mechanical condition, and this condition is more important than fertility; it warms up the soil and sets the plants quickly to work; it turns under the herbage when that herbage is soft and moist and when there is moisture in the soil, so that the herbage soon breaks down and decays. All catch crops on the orchard should be plowed under *just as soon as the ground is dry enough* in the spring, for these crops soon pump the water from the soil and cause it to bake and cement together, and the longer they remain the more difficult it is to cause them to rot when turned under. Hard and woody herbage plowed under late in the season, may remain as a foreign body in the soil all summer, breaking the connection between the upper and the lower soil and thereby preventing the upward movement of the water and causing the top soil to completely dry out. The chief value of crimson clover, rye, or other catch crop in the orchard, *lies in its fall growth and its protection of the soil in winter*, *not in its growth in spring.*

b. Tillage should generally be stopped in late summer or very early fall.— The tree has completed its growth. It must now ripen and prepare for winter. It can spare some of the moisture which comes with the fall rains. We may, therefore, sow some catch or cover crop. This crop will, if properly plowed under, greatly improve the mechanical condition of the soil; its roots will catch some of the leaching nitrates, of which the roots of the trees are now in little need; it will catch the rains and snows of fall and winter and hold them until they gradually percolate into the earth; it will prevent the puddling and cementing of the soil during winter; it will dry out the soil quickly in spring, if the plant is one

140.—Stand of Crimson Clover at Cornell.

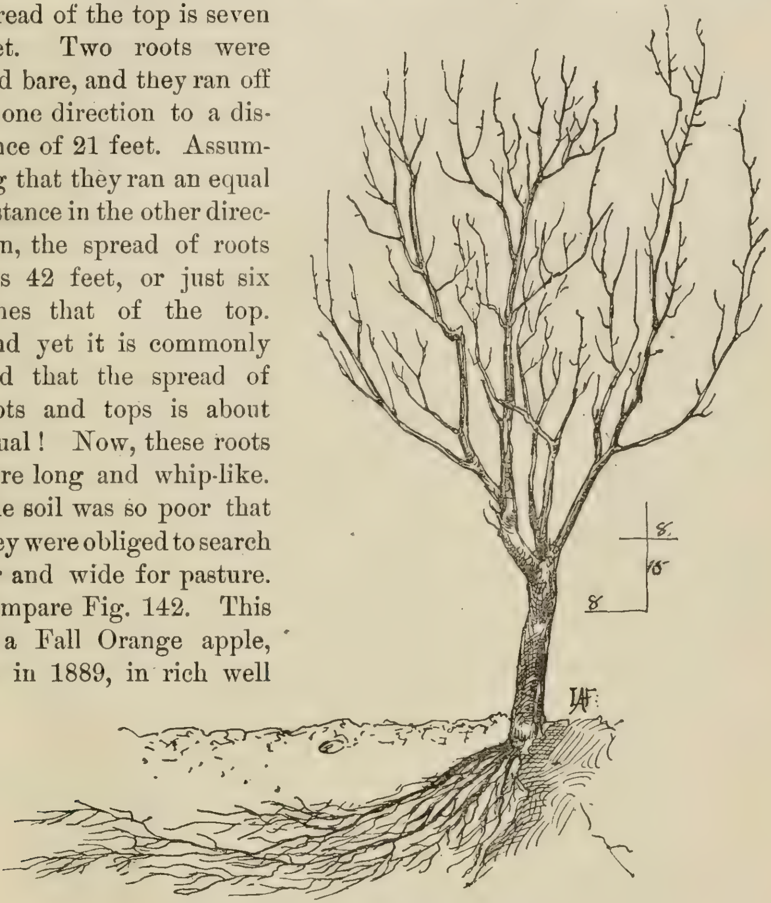
which survives the winter and starts early into growth, thereby making very early tillage possible. What this cover crop shall be must be determined by local conditions. It is probable that better results will be attained if different crops are used in different years, in a rough sort of rotation. Crimson clover is certainly one of the best. This is an annual. If sown too early, it becomes too mature in the fall and kills out; if sown too late, it secures insufficient root-hold and is killed by the winter. We now think that about the middle of July or the first of August is the safest time to sow it, under normal conditions, in this latitude. Fig. 140 is a view in a crimson clover patch on the Cornell plantation taken last spring, and for which the seed was sown the middle of July, 1894. Other good cover crops are peas, vetch, and possibly, now and then a year's crop of field clover. Oats, sowed corn, rape, spurry, buckwheat, rye, may be used occasionally.

c. Begin to till when the orchard is planted, and till the entire surface.— If trees are properly set and if cultivation is begun the first year, the roots will go deep enough to escape the plow. The roots of trees spread much farther than the tops. I will give some examples from trees of which we have carefully



141.—The roots of a pear tree, in hard tilled land.

measured the tops and roots. Fig. 141 shows a standard Howell pear tree set in 1889. It grows on a hard clay knoll. The full spread of the top is seven feet. Two roots were laid bare, and they ran off in one direction to a distance of 21 feet. Assuming that they ran an equal distance in the other direction, the spread of roots was 42 feet, or just six times that of the top. And yet it is commonly said that the spread of roots and tops is about equal! Now, these roots were long and whip-like. The soil was so poor that they were obliged to search far and wide for pasture. Compare Fig. 142. This is a Fall Orange apple, set in 1889, in rich well tilled soil. Here the roots are in good pasture and they remain at home; yet their spread is twice that of the top. The top of this tree had a diameter of 8 feet, and we were able to follow the roots 8 feet upon the side in which we dug. These object lessons enforce the importance of tilling all the land between the trees.



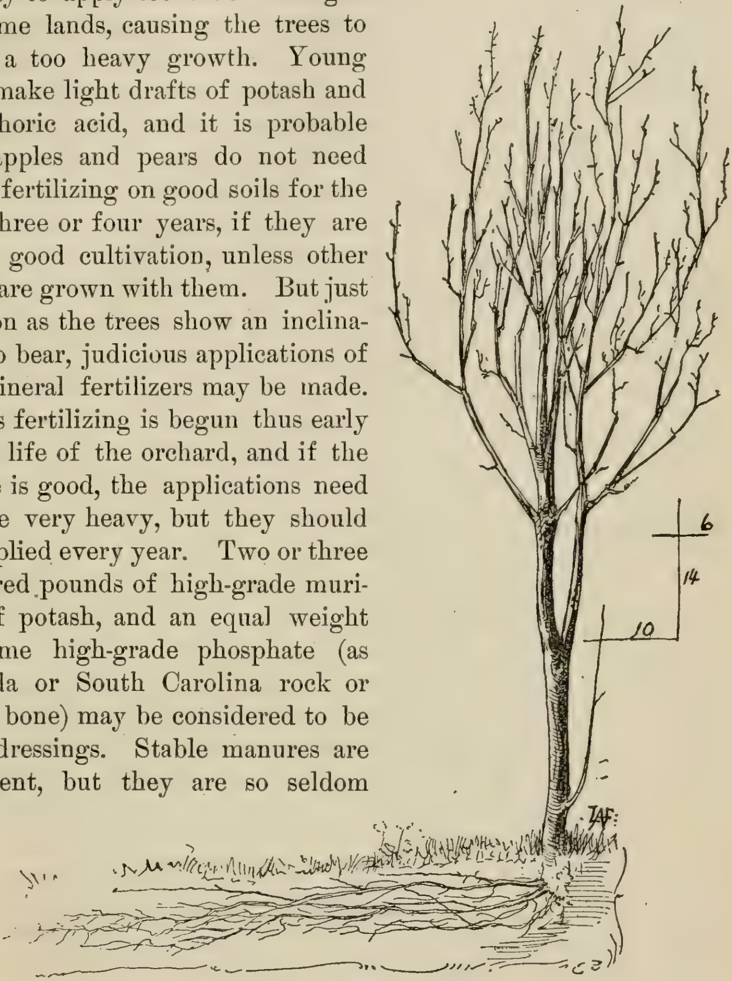
142.—Roots of an apple tree in good, tilled soil.

But these figures teach another lesson. Even at their highest point the roots of Fig. 141 are 8 inches below the surface. They escape the plow. A like remark applies to Fig. 142. Now, look at Fig. 143. This tree is the same age as the others, but has always stood in sod. The roots ran 10 feet in one direction and the total spread of the top was 6 feet, but the roots lie just underneath the surface. This land could not be plowed without great injury to the tree. Let us consider the relation of this tree to moisture; the roots are in the driest part of the soil; the grass is pumping out the water and locking it up in its own tissues, and sending it into the atmosphere with great rapidity; the soil is baked and pulls up the water by capillary attraction and discharges it into the air; there is no tillage to stop this waste by spreading a mulch of loose and dry soil over the earth. If one were to sink a well under this tree and were to erect a windmill and pump he could not so completely deprive the tree of moisture! And the less moisture the less food!

d. Cultivate in such manner that the land will be in uniform fine tilth.—Every good farmer knows that the value of his crop depends more upon the tilth of the soil than upon the richness of it. Fertility is largely locked up in poorly tilled lands. Orchards which are plowed late in spring are usually in bad condition all the season, especially if the soil is clay. Fall plowing upon stiff and bare lands is apt to result in the puddling of the soil by the rain and snow; if there is sod on the land this injury is less likely to follow. In general it is best to let orchard lands pass the winter under a catch crop.

4. *Lack of available plant food is unquestionably the cause of much of the failure of orchards.*— This fact is strongly emphasized in Bulletin 103, which shows that apple trees on a single acre may use, in the course of the twenty most productive years, over $400 worth of nitrogen, potassium and phosphorus; and if the owner wants large crops, the trees must have a still larger amount of food. The soil itself is a great storehouse of plant food, and this treasure is unlocked by the judicious tillage which I have recommended, but plant food must be added also to the soil if the best results are desired. It should be said, however, that no amount of fertilizer can atone for neglect of cultivation, for unless the soil is in congenial mechanical condition the plant is incapable of utilizing the food which may be applied. The better the tillage, the greater the benefit which comes from the use of fertilizers.

There is much yet to be learned respecting the fertilizing of orchard lands. In general, nitrogen can be supplied in sufficient quantity by thorough tillage and the use of occasional cover crops of crimson clover, peas or vetch. In fact, it seems to be easy to apply too much nitrogen on some lands, causing the trees to make a too heavy growth. Young trees make light drafts of potash and phosphoric acid, and it is probable that apples and pears do not need much fertilizing on good soils for the first three or four years, if they are given good cultivation, unless other crops are grown with them. But just as soon as the trees show an inclination to bear, judicious applications of the mineral fertilizers may be made. If this fertilizing is begun thus early in the life of the orchard, and if the tillage is good, the applications need not be very heavy, but they should be applied every year. Two or three hundred pounds of high-grade muriate of potash, and an equal weight of some high-grade phosphate (as Florida or South Carolina rock or fossil bone) may be considered to be good dressings. Stable manures are excellent, but they are so seldom to be had in sufficient quantity that they are practically beyond reach. A leading virtue of the stable manures is the vegetable matter which they contain and which puts the soil into good mechanical condition; but this fiber can also be had by the use of cover crops.



143.—Roots of an apple tree in sod.

In nursery lands, the soil is injured in its mechanical texture by the methods of cultivation and treatment. The best nursery lands are the "strong" lands, or those which contain a basis of clay, and these are the ones which soonest suffer under unwise treatments. The nursery land is kept under clean culture and it is therefore deeply pulverized. There is practically no herbage on the soil to protect it during the winter. When the crop is removed, even the roots are taken out of the soil. For four or five years, the land receives practically no herbage which can rot and pass into humus. And then, the trees are dug in the fall, often when the soil is in unfit condition, and this fall digging amounts to a fall plowing. The soil, deeply broken and robbed of its humus, runs together and cements itself before the following summer; and it then requires three or four years of "rest" in clover or other herbage crop to bring it back into its rightful condition. This resting period allows nature—if man grants her the privilege—to replace the fiber in the soil and to make it once more so open and warm and kindly that plants can find a congenial root-hold in it.

5. *All remedial treatments are generally begun too late in the life of the orchard.*—It is probable that plants become fixed in their habits by living long in uniform conditions, and that this habit is not readily broken. At all events, every observing horticulturist knows that it is often a difficult matter to induce in plants a habit of life which is directly contrary to the accustomed one. Apple trees should bear well when they are ten years planted. If they have not established a bearing habit by the time they are twenty years old, it may be a difficult matter to impress a new character upon them then. Whilst we advise the plowing up and pruning of all neglected and profitless orchards, we can not hope that this treatment will always rescue the most confirmed cases of unproductiveness. By the time an apple orchard is eight or ten years old, the owner should begin to see indications of its probable future behavior, and he should then begin his endeavors towards any change which he desires to bring about.

If an old or mature orchard still refuses to bear, it is likely that some radical change in the method of treating it may be useful. Many orchards develop a habit of redundant wood-bearing, and these are often thrown into fruiting by some check to the trees, as severe pruning, girdling and the like. Probably every orchardist has observed that the attacks of borers sometimes cause trees to bear. It is an old maxim that checking growth induces fruitfulness. This is the explanation of the fact that driving nails into plum and peach trees sometimes sets the trees to bearing, and also of the similar influence exerted by a label wire which has cut into the bark, or of a partial break in a branch. Girdling or ringing to set trees into bearing is an old and well known practice. It is not to be advised as a general resort, but I should not hesitate to employ it upon one or two of the minor branches of an unprofitable tree for the purpose of determining if the tree needs a check. I saw a Baldwin tree this year in which two large limbs had been girdled last year, and these limbs were bending with fruit whilst the remaining branches and the adjacent trees were barren. Girdling may generally be done with safety in spring when the leaves are putting out. A ring of bark two or three inches wide may be removed clear to the wood, and entirely encircling the limb. I have heard of excellent results following the simple ringing of trees, which consists in severing the bark — but removing none of it — completely around the tree with a sharp knife, in spring. These are, of course, only incidental operations to be employed with caution and then only upon branches of less importance. Their value is wholly one of experiment, to aid the owner in determining what fundamental treatment the orchard probably needs.

6. *Orchards are commonly grown on shares with other crops.*— There can be little objection to the growing of hoed crops in an orchard until the trees show signs of bearing, if the land is well tilled and the crops are liberally fed; but land can not be expected to give good yields of fruit and of other crops at the same time The worst of all crops for the orchard — and they are also the commonest ones — are hay and grain, because they allow of no tillage to conserve moisture and to alleviate the soil. It is well known that grass farming makes grass farmers; that is, continuous hay-raising sells off the fertility without replacing it and impoverishes the farm and eventually impoverishes the farmer. This is why our interior hill farms are now so much run down. What, then, shall we think of the farmer who expects to raise both hay and apples on the same land year after year?

If one wants to raise hay or grain, it is the cheapest to grow it where there are no trees to bother. If he wants to grow apples or grapes, he had better choose some other place than a meadow or grainfield.

7. *Failures are often caused or aggravated by neglect of pruning.*— There is less frequent neglect in this direction in western

New York than in the others which I have mentioned. Horticulturists have been well taught, by books, periodicals and nurserymen's catalogues, how to train and shape the plant, but there is very little good advice respecting the proper treatments of the orchard soil. Yet the apple orchard, which is the least productive of all our fruit plantations, is at the same time the very one which receives least attention in pruning. It is fair to assume that some of the failure is due to this inattention; and there is also sufficient direct experience to prove that careful and thorough pruning is essential to best results in fruit-raising.

8. *Much of the unprofitableness of fruit plantations is due to the incursions of insects and fungi.*—This is the subject which has latterly received the major part of the attention of persons who are engaged in studying the difficulties of fruit growing, and it is not strange that there has arisen a general belief that these enemies are the one chief cause of the failures of orchards. I am convinced that the experimenters have not overstated the destructiveness of the insects and fungi, but there is danger that the silence upon other and more fundamental matters in orchard economy, may tend to magnify the enemies beyond their comparative importance. I should not emphasize spraying less, but should emphasize tillage and other good care more.

The literature of spraying is now voluminous, and the farmer should be able to instruct himself upon all matters of immediate practical importance; but whilst he is spraying he should also not forget to look for borers, and to clean up old rubbish piles and waste places about the plantation.

9. *Profit and loss is often a question of varieties.*—Many orchards contain such an ill-assorted lot of varieties that even when the crop is good it is worth little. What varieties to plant is a local question. It can never be answered by experiment stations. It is one of those judgments which the farmer must make for himself and upon which very much of his success will depend.

The fruit grower should know by the time his apple orchard is twelve or fifteen years old if his varieties are likely to be satisfactory. He can generally find it out before this time. A man who does not find it out until his orchard is twenty or more years old has neglected his opportunities. If one discovers an error in choice of varieties before his trees have reached full maturity—whether the trees are apple, pear, cherry or plum—he should forth-with top-graft them. This top-grafting is sometimes profitable even in old trees, although it is usually unsatisfactory at that time.

In late years it has been observed that some varieties are commonly infertile with themselves; that is, the pollen of one variety is more or less impotent upon flowers of the same variety. The subject is little understood and it is not yet safe to generalize upon it; but it is a good practice to plant varieties in alternate rows or only two rows together, to insure free fertilization. Some of the varieties of apples and pears which have been studied in this respect (by Waite and Fairchild) are as follows:

APPLES.

Varieties more or less self-sterile.—Bellfleur, Chenango, Gravenstein, King, Spy, Norton Melon, Primate, Rambo, Red Astrachan, Roxbury Russet, Spitzenburgh, Talman Sweet.

Varieties generally self-fertile.—Baldwin, Codlin, Greening.

PEARS.

Varieties more or less self-sterile.—Anjou, Bartlett, Boussock, Clairgeau, Clapp, Columbia, Easter, Gray, Doyenne, Howell, Jones, Lawrence, Louise Bonnie, Mount Vernan, Sheldon, Souvenir du Congress, Superfin, Colonel Wilder, Winter Nelis.

Varieties mostly self-fertile.—Angouleme, Bosc, Buffum, Diel, Flemish Beauty, Kieffer, Le Conte, Manning Elizabeth, Seckel, Tyson, White Doyenne.

10. *It is probable that many trees fail to bear because propagated from unproductive trees.*—We know that no two trees in any orchard are alike, either in the amount of fruit which they bear or in their vigor and habit of growth. Some are uniformly productive, and some are uniformly unproductive. We know, too, that scions or buds tend to reproduce the characters of the tree from which they are taken. A gardener would never think of taking cuttings from a rose bush or chrysanthemum or a carnation which does not bear flowers. Why should a fruit-grower take scions from a tree which he knows to be unprofitable?

The indiscriminate cutting of scions is too clumsy and inexact a practice for these days, when we are trying to introduce scientific methods into our farming. I am convinced that some trees can not be made to bear by any amount of treatment. They are not the bearing kind.* It is not every mare which will breed or every hen which will lay a hatfull of eggs.

In my own practice, I am buying the best nursery grown stock of apples (mostly Spy), and am top-grafting them with scions from trees which please me and which I know to have been productive during many years. Time will discover if the effort is worth the while, but unless all analogies fail the outcome must be to my profit.

II. SOME REFLECTIONS UPON WEEDS.

The one deplorable fact in the minds of most farmers is the existence of weeds. From the time the boy is old enough to vent his energy in the smothered carrot bed, he is everywhere and always impressed with the fact that he must hoe to kill weeds. From youth to old age the burden is upon his mind and back. Writers of agricultural literature have taken up the wail, and have drawn it out to disproportionate lengths by specifying long lists of plants which are often weedy intruders, and by describing their habits and migrations in vivid detail. The truth is that weeds always have been and still are the closest friends and helpmates of the farmer. It was they which first taught the lesson of tillage of the soil, and it is they which never allow the lesson, now that it has been partly learned, to be forgotten. The one only and sovereign remedy for them is the very tillage which they have introduced. When their mission is finally matured, therefore, they will disappear because there will be no place in which they can grow. It would be a great calamity if they were now to disappear from the earth, for the greater number of farmers still need the discipline which they enforce. Probably not one farmer in ten would till his lands well if it were not for these painstaking schoolmasters, and many of them would not till at all. Until farmers till for tillage sake, and not to kill the weeds, it is necessary that the weeds shall exist; but when farmers do till for tillage sake, then weeds will disappear with no effort of ours. Catalogues of all the many iniquities of weeds with the details given in mathematical exactness, and all the botanical names added, are of no avail. If one is to talk about weeds he should confine himself to methods of improving the farming. The weeds can take care of themselves.

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* This subject was presented by the writer to the American Association of Nurserymen at the meeting in Indianapolis last June.

The presence of weeds is only one of the many illustrations of the effects of the desperate struggle for life which is forced upon every plant and animal when left to shift for itself. Every plant produces more seeds than it can ever expect to rear into plants. There is room for more only as other plants die. So when the farmer breaks up the earth he kills the plants which inhabited the land and thereby opens opportunities for the myriad host which stands waiting over the border for a chance to spread itself. These plants are bound to make the attempt to fill the breach. The farmer may keep them out either by killing them or preventing their establishment by means of tillage, or by covering the ground with other plants so that the weeds can find no chance to live. Now, these two things—tillage and cropping—comprise the whole science and practice of agriculture; and it follows that better farming is the only method of permanently keeping down the weeds. This fact is admirably illustrated by the common observation that those persons who are called "good farmers" complain least of weeds. It is often asked that the government lend its aid in directly fighting serious invasions of weeds; but the government can not take men's farms in charge and do their farming for them, and unless it does this it can only temporize with the invader.

Nature is a kindly and solicitous mother. She knows that bare land becomes unproductive land. Its elements must be unlocked and worked over and digested by the roots of plants. The surface must be covered to catch the rains and to hold the snows, to retain the moisture and to prevent the baking and cementing of the soil. The plant tissues add fibre and richness to the land and make it amenable to all the revivifying influences of sun and rain and air and warmth. The plant is co-partner with the weather in the building of the primal soils. The lichen spreads its thin substance over the rock, sending its fibres into the crevices and filling the chinks, as they enlarge, with the decay of its own structure; and finally the rock is fit for the moss or fern or creeping vine, each newcomer leaving its impress by which some later newcomer may profit. Finally the rock is disintegrated and comminuted, and is ready to be still further elaborated by corn and ragweed. So nature intends to leave no vacant or bare surfaces. She providently covers the railway embankment with quack grass or willows, and she scatters daisies in the old meadows where the land has grown sick and tired of grass. So, if I pull up a weed, I must quickly fill the hole with some other plant or nature will tuck another weed into it. Man is yet too ignorant or too negligent to care for the land, and nature must still stand at his back and supplement the work which he so shabbily performs. She knows no plants as weeds. They are all equally useful to her. It is only when we come to covet some plant that all those which attempt to crowd it out become weeds to us. If, therefore, we are competent to make a choice of plants in the first place, we should also be able to maintain the choice against intruders. It is only a question of which plants we desire to cultivate.

We must keep the land at work, for it grows richer and better for the exercise. A good crop on the land, aided by good tillage, will keep down all weeds. The weeds do not "run out" the sod, but the sod has grown weak through some fault of our own and thus the dandelions and plantains find a chance to live. So the best treatment for a weedy lawn is more grass. Loosen up the poor places with an iron garden rake, scatter a little fertilizer and then sow heavily of grass seed. Do not plow up the lawn, for then you undo all that has been accomplished; you kill all the grass and leave all the ground open for a free fight with every ambitious weed in the neighborhood. If the farmer occupies only half the surface of his field with oats, the other half is bound to be occupied with mustard or wild carrot or pigweeds; but if his land is all taken with oats, few other plants can thrive. So, a weedy farm is a poorly farmed farm. But if it does get foul and weedy, then what? Then use a short, quick, sharp rotation. Keep the ground moving or keep it covered. No Russian thistle or live-for-ever or Jimson-weed can ever keep pace with a lively and resourceful farmer.

Some two years ago I saw the much-described Russian thistle along the railroad track in western New York. "There," I said, "is your schoolmaster. It comes with all the energy and freshness of the west. It will bring new ideas. Presently it will invade our old orchards, and how it will shake them up! Then farming will mean cultivation or thistles. And now and then the farmer will debate if the old orchard is worth the trouble, and he will make wood of the trees and a potato-patch of the land, and everyone will be the gainer. If all that they say of it is true, this Russian thistle will beat the canker-worm and the apple-scab and the codlin-moth as a reformer. I am afraid that we need the Russian thistle."

And yet, I do not look for such a furious spread of this Russian thistle as it has enjoyed in the west; for even in the east we grow more wheat per acre than they do in Dakota. Six to ten bushels of wheat means that lots of land is left for the thistle; and to this must be added raw prairie, and waste land upon farms which are too big to be farmed; and still to these encouragements to the plant must be added the fault of wheat after wheat year by year. The reports say that 25,000 square miles of land are threatened to be made profitless for wheat by the Russian thistle. Then, upon so much area the advent of a mixed and self-sustaining husbandry will be hastened, and the Russian thistle should have all the honor of the achievement. The oncoming of the Canada thistle was proclaimed over a half century ago with the same forebodings of disaster. One New York agitator warned the people that it would "establish its fatal empire over the whole of North America," and perhaps result in the depopulation of the country! But whilst the Canada thistle has spread, it has met its Waterloo whenever it has made an onslaught against a good farmer. It is no longer dreaded by the farmers of this State. The land is now too precious to be given over to thistles. Now and then one sees a place like Solomon saw when he "went by the field of the slothful, and by the vineyard of the man void of understanding; and lo, it was all grown over with thorns, and nettles had covered the face thereof, and the stone wall thereof was broken down."

REVIEW.

I. Care of Fruit trees.—

- *A.* Sod-treatment of an orchard is a revival of the time when orchards were mere incidental accessories to the farm, and when the destiny of the apple was the cider barrel.
- *B.* No one cause can be assigned for all the failures of orchards to bear. The cause may be different for each orchard, and its determination, therefore, is a local question in each instance. The experimenter can discover the various agencies which may make orchards to be unproductive, but he may not be able to ascertain which one, or which combination of them, may affect any given orchard.
- *C.* The orchardist is to discover the cause of his failures, first, by acquiring a knowledge of the fundamental requirements of fruit-trees, and, second, by carefully watching and studying and experimenting with his own plantation.

D. Some of the leading agencies or errors which lie at the bottom of the unproductiveness of orchards are as follows:

a. The plantation lacks plan and forethought.

b. The land is often unsuited to the purpose, particularly in respect to its aspect, drainage, and general physical make-up.

c. Neglect of tillage or cultivation is probably the most universal fault.

This tillage should begin early in the season;

It should be stopped in late summer or early fall;

It should begin when the orchard is planted and should be applied to the entire surface; and

It should be performed in such manner as to keep the land in fine and uniform tilth.

d. Lack of plant food is probably a common cause for failure.

e. Good treatment may be begun too late, after the habit of the trees has become too thoroughly established to be readily broken.

f. It is a common effort to raise annual crops in bearing orchards, and to allow the trees only the skim milk.

g. Pruning is often neglected.

h. Insects and fungi may hold a mortgage on the crop.

i. Poor or ill-sorted varieties render many orchards unprofitable.

j. Trees may be expected to be unproductive if they are propagated from unproductive trees.

II. Weeds.—

Weeds are feared by those farmers who have made some mistake in the management of their fields, by virtue of which the weeds have found a chance to prosper.

Weeds, therefore, may be said to have a mission—first to educate the farmer, and second, to ameliorate the soil.

Good and judicious tillage and croping are the only effective means of keeping down weeds. A foul place can be cleaned by inaugurating, for a time, a short and vigorous rotation of crops.

The Russian thistle, which is now so much dreaded, may be depended upon to still further improve the practice of farming. If it spreads seriously, it will be because our scheme of farming allows it to spread by not keeping the land in full use; it must therefore be checked by more intensive and careful farming, and this will be a distinct reform.

L. H. BAILEY.

BULLETIN 103—October, 1895.

Cornell University—Agricultural Experiment Station.
AGRICULTURAL DIVISION

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SOIL DEPLETION

IN RESPECT TO THE

CARE OF FRUIT TREES.

By I. P. Roberts.

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BULLETINS OF 1895.

84. The Recent Apple Failures in Western New York.
85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
90. The China Asters.
91. Recent Chrysanthemums.
92. On the Effect of Feeding Fat to Cows.
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95. Winter Muskmelons.
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98 Cherries.
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100. Evaporated Raspberries in Western New York.
101. The Spraying of Trees; with Remarks on the Canker-Worm.
102. General Observations Respecting the Care of Fruit Trees; Weeds.
103. Soil Depletion in Respect to the Care of Fruit Trees.

Ithaca, N. Y., *October* 15, 1895.

To the Honorable Commissioner of Agriculture, Albany, N. Y.:

Sir.—In recent years many apple orchards of the State, especially those in western New York, have not produced satisfactorily. Various reasons have been given to account for the many failures, such as an unusual number of fungous enemies, late frosts, dry seasons, and cold wet weather at blooming time, and the like.

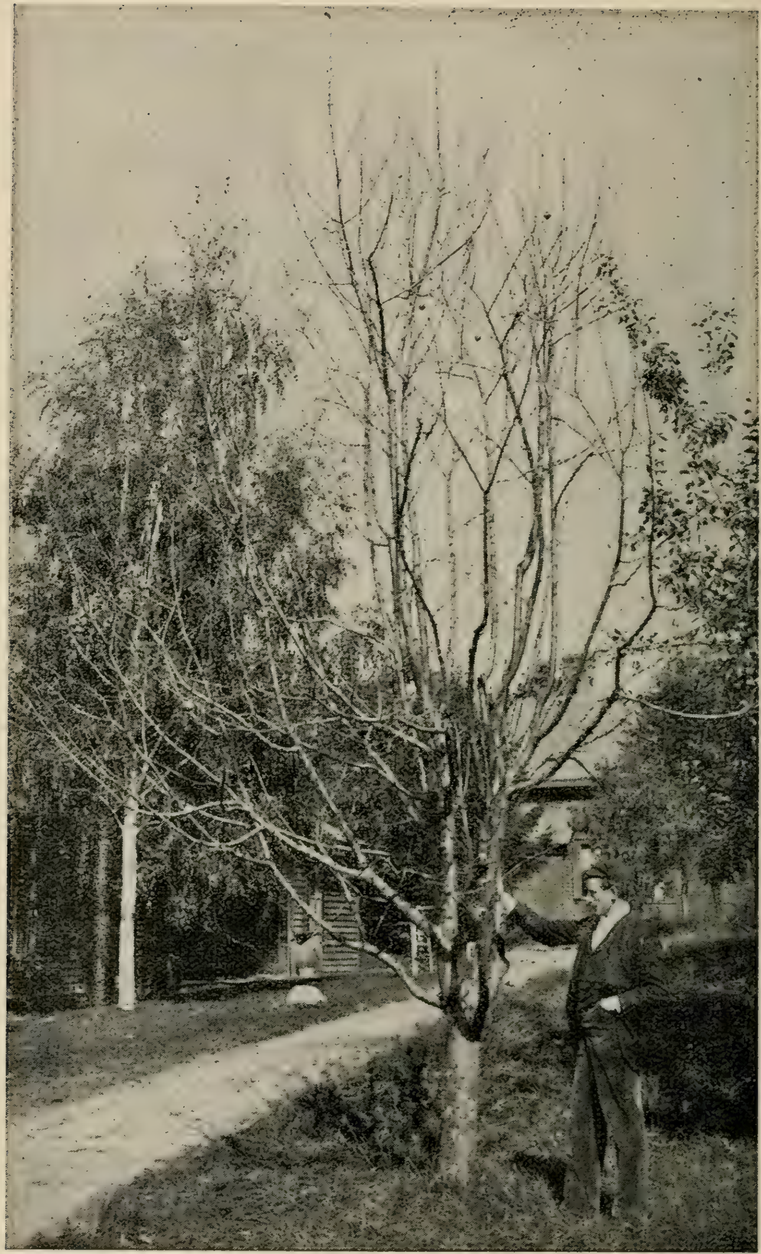
It is only recently that fruit-growers have come to mistrust that partial soil exhaustion of these old orchards, which have not only borne fruit for a quarter of a century or more but also grain and grass, is really a primary cause of the trouble.

The question is also frequently asked, why nursery trees may not be successfully raised continuously under good culture for a considerable number of years on the same land. It has long been known that a crop of nursery trees does not remove large amounts of plant food, and investigations appear to prove that the roots of nursery stock do not in any sense poison or injure the land; so that some other explanation than soil exhaustion must be found to explain the reason for nursery trees failing to give good results when preceded by nursery trees.

The following investigations have been undertaken in the hope that some light may be thrown upon the question of the depletion of the soil by fruit trees, a subject which is now attracting wide attention.

Very respectfully yours,

I. P. ROBERTS.



144.—The Wagner apple tree chosen for experiment. (See page 621.)

Care of Fruit Trees.

I. SOIL DEPLETION BY ORCHARDS.

The following experiments have been made in order to determine so far as possible the amount of plant food which is taken from the land by old and young apple trees and their fruit. It can be well understood how difficult the problem is. Few experimenters have gleaned in this field. The condition under which such investigations must be conducted are such that entire accuracy can not be secured, but it is believed that the results of these experiments may throw valuable light upon the exhaustion of orchard and nursery lands; or they may partially explain the failure of orchards to produce continuously, and the cause of the unsatisfactory results which are reached by the continuous cultivation of nursery stock on the same land.

On October 1, 1894, a healthy, normal-sized Wagner apple tree, thirteen years from planting, about 18 to 20 feet high, having a trunk 7½ inches in diameter (2 feet from the ground), was selected for an analysis of the leaves. A cut of it is shown in Fig, 144. The tree was grown in uncultivated land, although the grass had not formed a thick turf about it. The ground was naturally well drained. The land near the tree was somewhat depressed and at times received the wash from the land above. In former years a stone underdrain had been placed in the draw and served to carry off the water which issued from a small spring a few rods beyond the tree. It is probable that the roots of this tree had access to an abundance of moisture. The tree had been moderately pruned in past years, but had borne few apples. At the time the leaves were picked, a few sprouts had started from the larger limbs. They were all of the present year's growth.

The picture (Fig. 144) shows the general upright form of the tree. At the present writing, October, 1895, the tree has more of a spreading form, as it has produced five bushels of apples during the present season. It bore a few apples in 1893 but none in 1894. The leaves were green and fully mature when picked. The details of the sapling and caring for the leaves until they reached the chemical laboratory are unnecessary. Suffice it to say, that every precaution was taken to prevent any change from evaporation or other causes between the time of picking and the time when they were handed over to the chemist,* October 1st, for analysis.

Table I.

Leaves from a Wagner apple tree 13 years old, 18 to 20 feet high.
Total weight of leaves.................33.18

Composition of Original Substance.

	Ash.	Nitrogen.	Phos. acid.	Potash.
Water, 47.98%				
Dry substance, 52.02%............	9.53%	1.85%	.488%	1.76%

The above table shows from the small per cent. of water, that the leaves had performed their full functions and that no more changes in the ash content were likely to take place.

The Handbook of Experiment Station work gives the composition of apple leaves collected at various times as follows:

Table II.

	Water.	Ash.	Nitrogen.	Phos. acid.	Potash.
In May..................	72.36%	2.33%	.74%	.25%	.25%
In September...........	60.71	3.46	.89	.19	.39

If the leaves of the tree experimented with had been collected in May and had contained as much water as is shown in the last table, there would have been 50 pounds instead of 33.18 pounds. It is probable that the first table shows more nearly than the second the percentages of fertilizing constituents taken from the soil by the leaves.

The following gives the total weight and content of the leaves of the single apple tree and also the amount of plant food contained in an acre of like character, assuming that the trees were set 35 feet apart, which would give 35 trees per acre:

Table III.

	Single tree. lbs.	Amt. per acre. lbs.
Total weight leaves..................................	33.18	1161.3
Total weight water..................................	15.92	557.2
Total weight dry matter..............................	17.26	604.1
Total weight nitrogen................................	.29	10.15
Total weight phosphoric acid..........................	.08	2.80
Total weight potash..................................	.28	9.80

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* The analytical work of this Bulletin was performed by Mr. G. W. Cavanaugh under the direction of Professor G. C. Caldwell.

Assuming that 35 trees would bear, in five years from the time they were 13 years of age, 25 bushels of apples per tree or five bushels to the tree per year, and assuming that the composition of the apples were as given below, the results reached are:

TABLE IV.

Average Composition of Apples.

Water.	Nitrogen.	Phosphoric acid.	Potash.
85.3 %	.13 %	.01 %	.19 %

TABLE V.

Amount and value of fertilizing material used by the leaves and fruit in first period of five years.

	Apples. lbs.	Leaves. lbs.	Value.
Nitrogen	55.4	50.75	$15 92
Phosphoric acid	4.25	14.	1 28
Potash	80.95	49.	5 85
Total value			$23 05

Assuming that in the next five years, the trees would bear 10 bushels per year, or 50 bushels per tree in all, and that the leaves had increased in the same ratio as the apples, the following results are reached for the second five years:

TABLE VI.

	Apples. lbs.	Leaves. lbs.	Value.
Nitrogen	110.8	101.50	$31 85
Phosphoric acid	8.50	28.	2 56
Potash	161.90	98.	11 69
Total value			$46 10

Assuming that the trees have reached fair maturity at twenty-three years from setting, and that they produce on an average 15 bushels of apples per tree per year for the next ten years, and that the leaves have increased correspondingly, the following results are reached for the third period of ten years:

TABLE VII.

	Apples. lbs.	Leaves. lbs.	Value.
Nitrogen	332.40	304.50	$95 54
Phosphoric acid	25.50	84.	7 67
Potash	485.70	294.	35 09
Total value			$138 30

The following table gives the total plant food in leaves and fruit and its value for a single acre (nitrogen, phosphoric acid and potash being computed in all cases at 15, 7 and 4.5 cents per pound respectively) for the whole bearing period of twenty years, from the time the tree was 13 years old from setting until it was 33 years old:

TABLE VIII.

	Apples. lbs.	Leaves. lbs.	Value.
Nitrogen	498.60	456.75	$143 30
Phosphoric acid	38.25	126.	11 50
Potash	728.55	441.	52 63
Total value			$207 45

While the above results are reached by assuming a given amount of apples and leaves per year in a bearing orchard, and while the facts in any given case at any given time may vary widely, yet it is believed that they are valuable as they furnish a means of measuring in any given case, with a great degree of accuracy, the amount of soil exhaustion.

Table V. shows that 5 bushels of apples remove in round numbers 11 pounds of nitrogen, nearly 1 pound of phosphoric acid and 16 pounds of potash, and that the leaves of a tree large enough to produce the apples would contain 10 pounds of nitrogen, nearly 3 pounds of phosphoric acid and 10 pounds of potash, or a total of 21 pounds nitrogen, 3 pounds phosphoric acid, 26 pounds potash.

It will be seen how easily the other tables can be used to determine approximately the amount and kind of plant food used by apple trees in any given case.

In a given year, a mature tree might produce as many apples as the amount assumed and in another year fail to produce any, yet a computation could be made from the data given which would throw much light on the vexed question of orchard soil exhaustion.

No attempt has been made to estimate the amount or value of the leaves which are blown into the fence corners or onto adjoining fields, nor those which remain on the land. The good judgment of the orchardist can make these estimates according to exposure and local conditions with a good degree of accuracy. In the investigation of soil exhaustion by nursery stock, which follows, no account has been taken of the leaves, as the wind has but little effect where the trees are so low-headed, and so numerous as they are in the nursery row.

As a clearer comprehension is had by comparing unfamiliar things with familiar things, a table follows which gives in brief the soil exhaustion which is likely to occur from a continuous twenty-year wheat production. Here, again, an average yield has been assumed which, while approximately correct for New York, may be wide of the mark in some States where the average yield of wheat falls to 8 or 10 bushels per acre.

The following tables show the amounts and value of the fertilizing ingredients removed by wheat (grain and straw) in twenty years continuous cropping, assuming an average yield of 15 bushels per acre and 7 pounds of straw to 3 bushels of grain:

TABLE IX.

Composition of Wheat and Straw.

	Water.	Nitrogen.	Phosphoric acid.	Potash.
Grain	14.75%	2.36%	.89%	.61%
Straw	12.56	.559	.12	.51

TABLE X.

Amounts and value of plant food removed in one year and in twenty years.

	Nitrogen. lbs.	Phosphoric acid. lbs	Potash. lbs.	Total value.
Grain, 1 year	21.24	8.01	5.49	$3 99
Grain, 20 years	424.80	160.20	109.80	79 86
Straw, 1 year	11.74	2.52	10.71	2 42
Straw, 20 years	234.78	50.40	214.20	48 37

Total value in wheat, grain and straw for 20 years	$128 23
Total value in apple, fruit and leaves for 20 years	207 45

The above table shows that the orchard requires, if fruitful, plant food equal in value to $87 more than the wheat. No one would think for a moment of trying to raise, even on our best New York land, wheat for twenty consecutive years, even though the soil was fitted in the best possible manner yearly.

The following investigations show the amount of patent food demanded or used by old orchard trees. The old apple orchard on the University farm, largely body-grafted, set at the beginning of the century, situated on gravelly soil, with stone and sand subsoil at the depth of from three to six feet, was seeded in 1876 to permanent pasture. Only about one-third of the trees of the original orchard still remained, and they bore little merchantable fruit. Some of the varieties were worthless, the trees were overloaded with brush, and looked like many trees one sees in passing through the country. The orchard, since seeding, has been pruned from time to time, and top-dressed with farm manures some three or four times. The field has never been grazed closely, and nearly every fall cattle have been fed coarse, supplementary food upon it.

Most of the trees soon showed increased vigor and fruitfulness. A Seek-no-further tree, nearly destitute of apples, in a fairly thrifty condition, but below the normal size of trees of its age (see illustration on page 617) was selected for the following investigations:

(1) Amount and composition of leaves.
(2) Amount and composition of wood, 1894.
(3) Amount and composition of wood, 1895.
(4) Amount and composition of limbs and trunk.
(5) Amount and composition of roots.

The work of picking leaves began July 1, 1895, and the final sampling of trunk and roots was completed July 12. The limbs, trunk and roots were sampled by sawing numerous pieces several times crosswise, thereby securing uniform samples of sawdust for analyses.

TABLE XI.

Leaves.

	Lbs.
Total weight	232.02
Total weight water	139.51
Total weight dry matter	92.51
Total weight nitrogen	.96
Total weight phosphoric acid	.37
Total weight potash	1.32

TABLE XII.

Twigs.

	(1895 growth.) Lbs.
Total weight	171.7
Total weight water	88.08
Total weight dry matter	83.62
Total weight nitrogen	.86
Total weight phosphoric acid	.31
Total weight potash	.67

TABLE XIII.

Twigs.

	(1894 growth.) Lbs.
Total weight	266.7
Total weight water	130.70
Total weight dry matter	136.
Total weight nitrogen	1.15
Total weight phosphoric acid	.35
Total weight potash	.80

TABLE XIV.

Limbs and Trunk.

	Lbs.
Total weight	3972.5
Total weight water	1656.53
Total weight dry matter	2315.97
Total weight nitrogen	5.16
Total weight phosphoric acid	1.99
Total weight potash	5.16

TABLE XV.

Roots.

	Lbs.
Total weight	840.5
Total weight water	424.87
Total weight dry matter	415.63
Total weight nitrogen	.92
Total weight phosphoric acid	.42
Total weight potash	.92

One large root was found to be entirely decayed, hence it is probable that the per cent. of roots as compared to tops is less than the average.

TABLE XVI.

Amount and value of leaves from an acre of trees.

	Lbs.	Value.
Total weight (one year)	8120.7	
Total weight nitrogen	33.6	$5 04
Total weight phosphoric acid	12.95	91
Total weight potash	46.2	2 08
		$8.03

The total value of the respective ingredients in the tree, including leaves is as follows:

TABLE XVII.

	One tree.	Value per acre (35 trees.)
Nitrogen	$1 36	$47 60
Phosphoric acid	24	8 40
Potash	40	14 00
	$2 00	$70 00

SUMMARY.

TABLE XVIII.

Total weight of wood from an acre of trees	5,251.4	lbs.
Value in planted food (nitrogen, phosphoric acid and potash)	$61.97	
Total weight of leaves from an acre of trees	8,120.7	lbs.
Value	$8.03	
Total value	$70.00	

Computing from Table XVI, the leaves of 35 mature trees (an acre) would require the following amounts of plant food in twenty years:

TABLE XIX.

	(Leaves.) Lbs.	Value.
Nitrogen	672	$100 80
Phosphoric acid	259	18 13
Potash	924	41 58
Total for twenty years		$160 51

If the amount of plant food required to grow the apples for twenty years be added to this, as shown in Table VII, which represents ten years, the following results are reached:

TABLE XX.

Apples.

	Lbs.	alue.
Nitrogen	664.8	$99 72
Phosphoric acid	51.	3 57
Potash	971.4	43 71
Total for twenty years		$147 00
Total for twenty years (leaves)		160 51
Total for life of tree (wood)		70 00
Grand total		$377 51

The value of nitrogen, etc., in any given case is so indefinite and variable that stress should not be laid on values as given above, but on the total amounts of plant food used by the orchard.

The total amount of nitrogen, exclusive of that used in the growth of the trees, is 1336.8 lbs., of phosphoric acid 310 lbs., and of potash 1895.4 lbs. To restore the potash alone, as above and that used by the growth of the tree, it would require 21.69 tons of high grade ashes containing 5 per cent. of potash. To restore the nitrogen as above, would require 16.19 tons per acre of a commercial fertilizer containing 5 per cent. nitrogen.

How much of this plant food is usually furnished to the orchard by leguminous plants and by feeding supplementary foods to animals which graze upon it and how much by the fallen leaves and apples which are not blown or carried off, can not be told.

While some of the computations and conclusions are based on estimates, yet it is believed that the tables represent average conditions and need only the good judgment of the observant reader to make them apply to his individual case with such degree of accuracy as to give valuable aid in the care and feeding of orchards.

Many old orchards have not only been making these large demands on the soil for the last twenty years, but in many instances the land has been used for the production of hay or grain, or more frequently for the growing of lambs and pigs with little or no supplementary food. The grazing of orchards, especially with growing animals without extra food, is as certain to deplete the land as grain raising, though the soil robbery is not so rapid.

These investigations, when considered in all their bearings, lead one to wonder not why old orchards are failing, but why they have not ceased to produce merchantable fruit long since.

II. SOIL DEPLETION BY THE GROWTH OF NURSERY TREES.

The object of this investigation was to determine the amount of fertility removed from the soil by the growth of various kinds of nursery stock. As both tops and roots are removed when the trees are sold they are both included in the investigation, although the proportion of tops and roots is given separately.

In October, 1894, twenty-four apple, pear, peach and plum trees, six of each kind (Fig. 145) were received from the firm of Smiths & Powell, Syracuse, N. Y. They were thrifty and straight, had been dug with care and were in every way suitable for planting in the orchard. The kinds were as follows:

Apple.	Pear.	Peach	Plum.
Pound Sweet,	Flemish Beauty,	Foster,	German Prune,
Nonesuch,	Seckel,	Wonderful,	Bradshaw,
Strawberry,	Sheldon,	Crawford Late,	Yellow Egg,
Fall Pippin,	Lawson,	Crawford Early,	Moore's Arctic,
Alexander,	Anjou,	Smock,	Washington,
Grimes' Golden.	Bartlett.	E. Beatrice.	Guii.

The roots were washed and dried, the trees weighed and photographed.

The six trees of the various groups weighed as follows:

TABLE XXI.

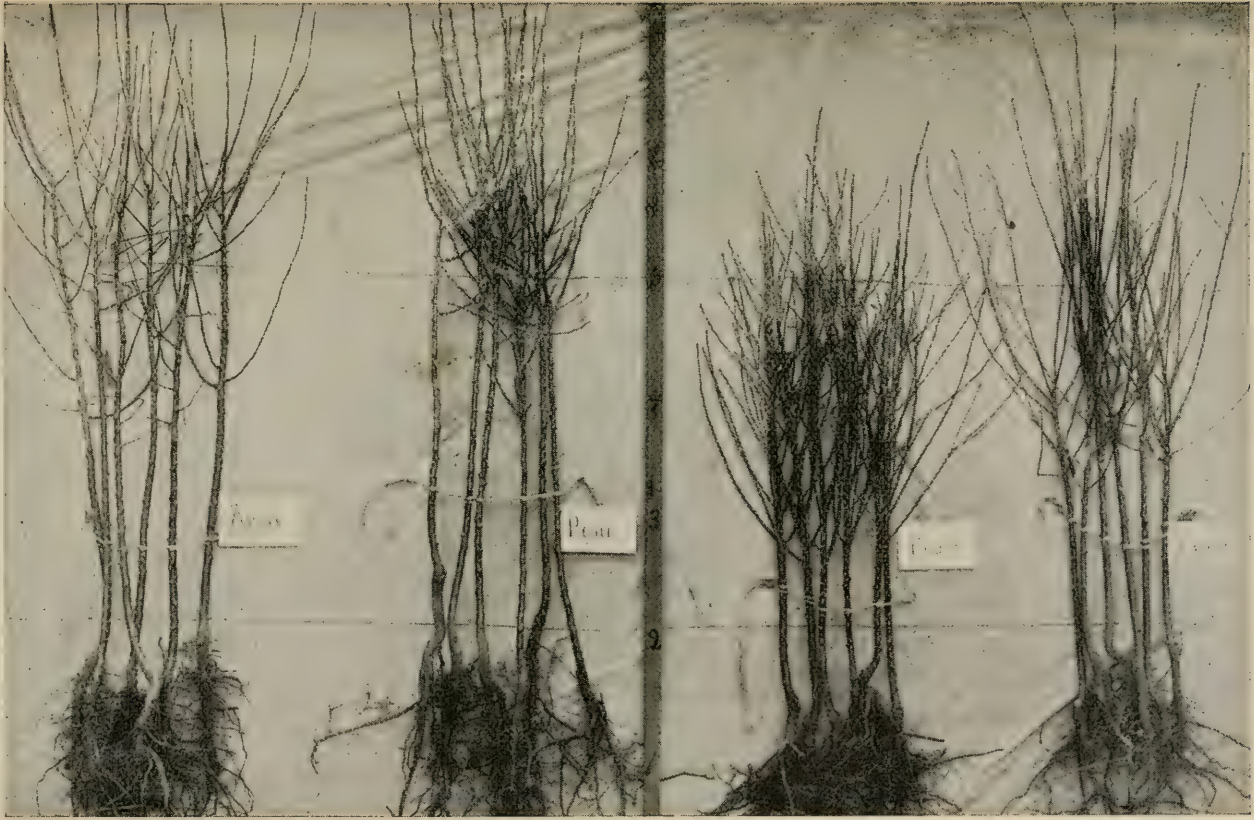
Apples.	Pears.	Peaches.	Plums.
7.6 lbs.	7.48 lbs.	6.6 lbs.	6.04 lbs.

The tops were severed from the roots at the point corresponding with the surface of the ground, as the trees had originally stood in the nursery row. The tops and roots were measured, weighed and prepared for the chemist by first running them through a strong fodder-cutter and then by grinding them in Mann's green bone-cutter.

TABLE XXII.

Nursery Trees.

	Weight of tops. Lbs.	Weight of roots. Lbs.
Apple	4.44	3.16
Pear	3.97	3.52
Peach	4.10	2.50
Plum	3.82	2.22



145.— he nursery trees which were analyzed.

Table XXIII.

	Average height of tops above ground.	Average length of roots below surface of ground.
Apple, six varieties	5 feet 8 inches	1 foot 10 inches.
Pear, six varieties	5 " 2 "	1 " 11 "
Peach, six varieties	4 " 6 "	1 " 7 "
Plum, six varieties	4 " 11 "	1 " 8 "

Table XXIV.

Composition.

(6 trees).	Apple. Lbs.	Pear. Lbs.	Peach. Lbs.	Plum. Lbs.
Total weight	7.30	7.28	6.34	5.68
Total dry matter	3.91	3.85	3.33	3.04

SUMMARY.

Table XXV.

	Lbs.	Lbs.	Lbs	Lbs.
Total nitrogen	.0218	.0298	.0269	.0237
Total phosphoric acid	.0076	.0094	.0095	.0053
Total potash	.0148	.016	.0141	.0138

The following quotation is taken from Smiths & Powell Co's. letter dated October 20, 1894:

"In regard to the number of trees per acre, I may say that the blocks vary, but an average yield per acre one year with another would be, pears, cherries and plums, 5,000; apples, 8,000."

The following table is made from these estimates and the tables above:

Table XXVI.

Amounts and value of fertilizing constituents removed from an acre of nursery trees. (They occupy the ground for about 3 years.)

	Apples.		Pears.		Peaches.		Plums.	
	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.	Lbs.	Value.
Nitrogen	29.07	$4 36	24.83	$3 73	22.42	$3 36	19.75	$2 96
Phosphoric acid	10.13	71	7.83	54	5.42	38	4.42	31
Potash	19.73	89	13.33	60	11.75	53	11.50	52
		$5 96		$4 87		$4 27		$3 79

The above results show conclusively that but a small amount of plant food is removed from the soil by the growth of nursery stock. They also show that more phosphoric acid is removed by the apples and pears than by the peaches and plums; but any ordinary soil, cultivated as nursery lands are, should easily furnish in three years ten times the plant food used by the trees. In order to compare the drafts made by nursery stock and some of the common crops raised in mixed husbandry, the following table is submitted:

TABLE XXVII.

The amount of green corn necessary to remove an equal amount of fertilizing ingredients per acre, taking the average of the value of the nitrogen, phosphoric acid and potash ($4.87) removed by an acre of the trees (three years' growth) would be 4,779 pounds.

Composition of Green Corn.

	Water.	Nitrogen.	Phosphoric acid.	Potash.
Corn..................	78.61 %	.41 %	.15 %	.33 %

Ensilage corn raised in drills usually yields from 12 to 20 tons per acre and yet does not make drafts on the land which precludes duplicating the yield the following season; hence some other cause than soil exhaustion must be found if the failure to grow a second crop of nursery trees without intermediate crops is explained.

If the plowing of clayey corn ground a few days before the land is dry enough to be at its best frequently causes a loss of half the normal crop, may not the digging of the trees or working the land when too wet result in equal injury to the second crop of trees if planted before the land has returned to its normal condition? The exacting demands made on the soil by nurserymen, and the locking up of available plant food by untimely culture and by digging the trees when the land is wet, may be held accountable for the failures until some better reasons can be found.

Nurserymen seldom follow nursery trees with nursery trees, as it is said that they never do well unless one or more crops of clover or grasses intervene. Since land which is intended for nursery trees is usually highly fertilized, summer fallowed and cultivated an entire season before the trees are set, and since it is well known that much of the fertility added to the land and made available by manuring and plowing is still in the soil after the first crop of trees has been removed, the question arises why do not nursery trees follow nursery trees kindly?

Jethro Tull, many years since, succeeded in raising wheat after wheat continuously without serious diminution of yield for twelve consecutive years. Lawes & Gilbert, of England, have also experimented largely in raising wheat continuously on the same ground. Like experiments have also been conducted at Cornell University. Six crops of wheat have been taken consecutively and seven of corn without an intervening crop. In the first instance, no grass or fertilizers of any kind were used. In the second, the field was treated to five tons of farm manures yearly. In all of these cases, there were no indications that the plants had exuded anything from their roots which was deleterious to subsequent plants of the same species, neither were there any indications that under superior culture, with or without fertilizers, reasonable success might not be secured without rotation. Of course it is well understood by the thoughtful investigator that there is usually great economy in rotation for various reasons which it is not necessary to state here.

Two reasons have been assigned for the failure to successfully raise nursery stock continuously on the same land. The first is, that the plants have exhausted all the readily available plant food, and since nursery stock, to be at its best, must have an early and rapid growth, it is impossible without weathering the land and allowing some of the plant food in the subsoil to rise to the surface to secure satisfactory results. It should be kept in mind in this connection, that under proper culture and conditions in dry weather, plant food rises from the subsoil to near the surface, while in very wet weather it may pass from the surface downward. Nursery trees get a large percentage of their nourishment from the subsoil, and during the two to five years that the ground is occupied by them, a portion of the available plant food in the subsoil is used. This would explain in part the difficulty of using land continuously for growing young trees.

Another reason has been assigned for the fact: nursery lands in trees are not always cultivated when the soil is in the best condition. So much is always to be done in the spring of the year, that the intervals between the rows are often plowed when the land is too wet or too dry. Again, the digging of the trees is usually performed late in the fall or early in the spring when the soil is little better than a mortar bed. The digging and trampling, especially on clay soils, when the land is in this condition, puddles it, and the larger part of the available plant food is locked up, and it requires one or two years of culture and even manuring to bring the land back to its normal condition. But all these explanations do not fully account for the imperfect growth of the second crop of trees, for after having removed the trees from the land, if it be thoroughly plowed and cultivated, there appears to be no difficulty in raising a good crop of wheat or grass.

In the haste to get the trees off at as early a period as possible the grower is not satisfied unless they are making *a rapid continuous growth;* that is, he asks more of the land in his method of farming than does the wheat or corn grower, and, therefore, as soon as the land hesitates in the least when planted to a second crop of trees he puts it down as a partial failure.

This explanation is emphasized by the fact that many orchardists have come to believe that nursery trees under present management are forced so rapidly and make such soft growth of wood that they are injured thereby. These trees which have been forced to unusual growth, when set in the orchards under less favorable conditions than were present in the nursery row, start slowly and frequently are unable to make a satisfactory growth of good wood for two or three years.

The following letters from careful nurserymen will throw additional light upon the perplexed question of management of nursery lands:

For the production of apples in the nursery I prefer a good strong loam. If a little gravel is mixed with it there is no objection. For plums, soil considerably heavier, even to a pretty strong clay, is more desirable. The same may be said to apply to pears. For peaches a soil more nearly to that which I would advise for apples is best.

The preparation of the ground is a matter of considerable importance, and I would always advise very deep plowing; or even subsoiling after ordinary plowing would be better. As for fertilizers, have never used any in the production of trees. I prefer new, strong land that is supplied with the proper amount of plant food instead of using anything in the way of stimulants. In my own experience I have found that I can with safety take off one crop of seed fruits, such as apples or pears, and if the soil is strong, follow with cherries or peaches, but this is keeping the soil under the plow for a period of from five to six years, and most soils lose more or less of their life and are inclined to become hard after plowing if they have no rest. In order that you may understand the matter better, WE MAKE our trees by thorough and continued cultivation, and I undertake to say the best of trees can be grown in no other way. Our blocks are plowed and cultivated probably not less than six or eight times during the season of growth. You can easily understand what this means. To us it means to get out everything in the soil that is reachable for the purpose of aiding the growth of the trees. The reason, in my opinion, that the land will not produce a second lot of good trees is that we manage to get the most of the tree-growing properties out of the soil in the first crop.

S. D. WILLARD.

For the culture of pear and plum trees we prefer a strong clay loam, thoroughly underdrained and fertilized sufficiently to grow a first-class crop of wheat or corn.

For apples we prefer a more loamy soil, prepared in a similar manner to above.

Peach and cherry will thrive on a much lighter soil.

We do not approve of planting one crop of nursery trees immediately after another, for the reason that the crop exhausts the soil of those elements that are peculiarly requisite for the growth of that particular kind of plant. We, however, frequently follow a planting with that of some other kind of plant and with good success we think; for example, we plant cherries after pears and peaches after apples.

SMITHS & POWELL CO.

In reply to your inquiry as to best land for growing nursery stock we will be brief as possible.

(*a*) Apples.—(1) Upland clay loams, that is as high up as you find clay. (2) Heavy sand loam. (3) Gravelly soils that contain more soil than stones.

(*b*) Plums.— Clay loam *very rich for years with barnyard manures;* character of soil not so important as richness and thorough drainage.

(*c*) Pears.— The best standard pears are produced on soils mostly clay with clay subsoil, thoroughly underdrained.

(*d*) Peaches.— A natural soil for a block of peaches is a chestnut upland, *i. e.*, a soil where the American sweet chestnut is indigenous; high, sandy soils, if rich from a farmer's standpoint, will do well.

For *a*, *b* and *c* we select lands that can be easily drained, a natural slope, good fall, ditch 2½ feet deep, 2 rods apart; plow in August or September; rot all sods; then plow before cold weather, prior to spring planting, 12 inches deep.

Suitable land, treated thus and followed up with thorough cultivation will give satisfactory growth to trees, always excepting such risks as hail, winter killing, aphides, fungi, etc.

The above contemplates ordinarily good land without fertilizing, but we should use stable manures for plums and apples, and depend on our good subsoil and thorough cultivation for a growth of pears.

We have blocks of apples raised as a second and a third crop by using 25 to 30 bushels of wood ashes and lime (air slacked, the waste from lime kilns). Apple wood always improves with wood ashes and lime, even on limestone lands.

Clay lands will produce more than one crop of trees to advantage, without fertilizing, if not "killed" by working too wet. It takes a long time to recover soil spoiled in this way and the only cheap way to reinstate it is to grow clover, corn, potatoes or something. It is well to plow under clover, rye or corn.

We like the following rotation of crops if the land lies right:

Apples after Plums or Cherries or Peaches.
Plums after Apples or Pears.
Peaches after Apples or Pears.
Cherries after Apples or Pears.

We never grow a poor crop of wheat after a crop of trees.

We have never seen good results after use of ordinary commercial fertilizers.

We like stable manure, but it is very expensive in quantities that produce results, hence we try to get lands that have not been treed before.

Wood ashes and lime never fails us.

Our opinion is that lands that do not produce a second crop of trees are not adapted to trees at all, or that the "life" has been trampled out of it while wet and that fertilizers are not as necessary as proper mechanical reconstruction.

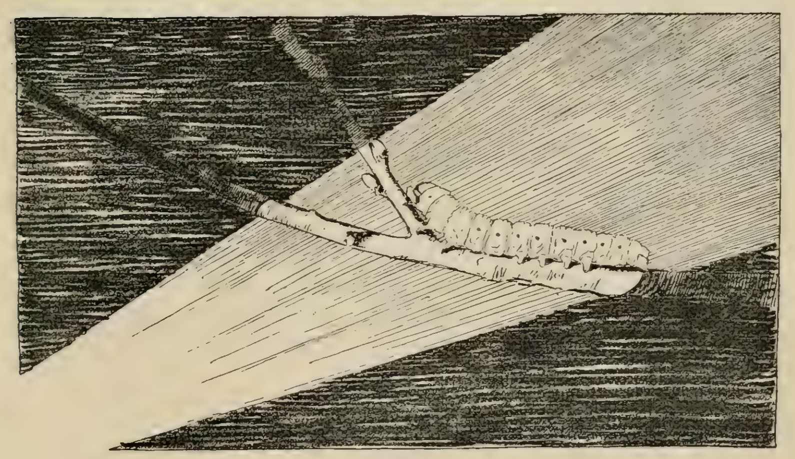
GEO. G. ATWOOD.

BULLETIN 104—November, 1895.

Cornell University—Agricultural Experiment Station.
ENTOMOLOGICAL DIVISION.

CLIMBING CUTWORMS

IN WESTERN NEW YORK.



By M. V. Slingerland.

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The regular bulletins of the Station are sent free to all who request them.

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Cornell University,
Ithaca, N. Y., *November* 16, 1895.

Honorable Commissioners of Agriculture, Albany:

Sir.— Although cutworms are amongst the most familiar of insects, their habits are yet little known to most persons. This is particularly true of those species which ascend young trees at night and eat out the buds. These climbing cutworms have done much mischief in parts of western New York in the last year or two, and Mr. Slingerland has taken up the study of them under the auspices of the Experiment Station Extension bill, and this account of his researches in the field and laboratory is submitted for publication under that law (Chapter 230, Laws of 1895). The need of this investigation is the greater because these worms are afield in the most unseasonable hours of the night, when their depredations escape the observation of the fruit-grower. Many persons regard them with especial apprehension from the fact that, aside from the havoc which they make, they seem to demand that if the grower plants trees in the daytime, he must stand by them all night. Fortunately, such exacting requirements are not necessary; and, being assured at the outset that the later pages of the bulletin contain efficient directions for circumventing the injury, the farmer may read the histories and habits of these interesting insects with composure.

L. H. BAILEY.

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Climbing Cutworms.

I. CUTWORMS IN GENERAL.

Although this bulletin treats primarily of climbing cutworms, it seems advisable to devote a few pages to a discussion of cutworms in general.

What are They?

Cutworms are the caterpillars of certain moths belonging to a great family of insects known as Noctuids or owlet-moths. Most of the moths or "millers" that fly into our houses at night, attracted by the lights, are members of this family. Several different kinds of cutworms are represented, about twice natural size, on the plates in this bulletin.

Habits of Cutworms.

Many different kinds of grubs and caterpillars have a peculiar habit of often cutting off their food-plants near the surface of the soil; these were all commonly known as "cutworms" to the earlier writers on insects.* About seventy-five years ago, writers began to restrict the name to the caterpillars of owlet-moths only; and all of these had the peculiar habit of concealing themselves during the day, either beneath some object on the ground or buried just beneath the surface, and of coming forth to feed only at night. More recently, several Noctuid caterpillars with noc-

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*When and by whom the name "cutworm" was first used, we have been unable to discover. It first appeared in a dictionary in 1808 as a Scottish word designating "a small white grub, which destroys coleworts and other vegetables of this kind, by *cutting* through the stem near the roots" (Jamieson's Dictionary of the Scottish Language); it is doubtful if this definition refers to a Noctuid caterpillar. As the term was quite commonly used in communications read before the Philadelphia Society for the promotion of Agriculture in 1816 and 1817, it is probable that it has been in use in this country for a century or more. The name may still be in use in Scotland, but it seems to have never come into use in England or in any other country except America. For the past seventy-five years it seems to have appeared only in American literature. In England, the term "surface caterpillars" is used, and the Germans call them "erdraupen" or "eulenraupen."

turnal, but not with cutting, habits have been classed as cutworms; they usually feed at night upon the leaves of low plants in the same manner as the day-feeding caterpillars.* All cutworms usually curl up when disturbed. Several species cut off the plants at the surface, others an inch or so above, while one cutworm (*Hadena devastatrix*) rarely appears above the surface, but works on the roots and stems just beneath. Sometimes cutworms draw the several plants or leaves as far as possible into their day retreats where they can continue their feast at leisure.

Under certain conditions, however, cutworms may change their usual habits. In several instances, true cutworms (*Feltia herilis* and *Noctua fennica*) have appeared in enormous numbers and have then assumed the army-worm habit of traveling in hordes and feeding by day. Many of the species also know how to get to the tender buds of fruit-trees or grape-vines when there is a scarcity of their favorite food-plants to cut off. But little is definitely known of the habits of young (less than half grown) cutworms; they are said to work in a similar manner as when nearly full-grown but owing to their small size, do little damage to the mass of vegetation.†

There are known to occur in our state at least thirty different kinds of cutworms, and as many more Noctuid moths whose caterpillars may have cutworm-habits; nothing is yet known about the habits of many owlet-moth caterpillars.

APPEARANCE AND HABITS OF THE MOTHS.

The moths — the parents of the cutworms — are also nocturnal in habit. They rest during the day in sheltered spots on trees, fences, and other suitable localities; often their coloring so closely mimics their surroundings that they are practically invisible to the untrained eye. They feed upon the nectar of flowers and other sweet exudations of plants, and are readily attracted to lights. As a rule, they are of a somber grey or brown color with their wings obscurely marked. The size and general appearance of several of the species are well represented in the figures on the plates in this bulletin. Their nocturnal habits, and the fact that often when in obscurity their eyes shine very brightly, suggested their common name, owlet-moths.

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* According to Miss Murtfeldt (U. S Bull. 13, p. 60) and Dr. Lintner (Ent. Contrib., IV, 93) two species (*Rhynchagrotis alternata* and *Homohadena badistriga*) of cutworms hide on the trunk and branches of their food-plants during the day.

† In some species, at least, the young cutworms, before they shed their skin the first time, are semi-loopers, that is, one or two pairs of pro-legs have not yet appeared and they "loop" themselves along like measuring-worms. During this stage they probably feed on the plant on which the eggs were laid, but after the first moult they have the normal number of legs, sixteen, and assume regular cutworm habits.

APPEARANCE OF CUTWORMS.

Cutworms are sleek, fat-looking caterpillars ranging, when full-grown, from an inch to nearly two inches in length. They are dull yellowish, whitish, greenish, or greyish in color, and often striped, clouded, or variously marked with dull black or brown; sometimes deep black or distinct white markings occur. A few hairs arise from darkish, regularly arranged spots on the body. All cutworms have six true legs and ten fleshy pro-legs, and usually the head and a horny shield on the back of the next segment are dark colored. Several of these characteristic features are well shown in the figures of the different cutworms on the plates.

FOOD-PLANTS.

Cutworms are not at all fastidious in their diet, but they prefer the succulent crops of the garden, especially corn, cabbages, tomatoes, onions, beans, etc. They also often work great destruction to grass, wheat, barley, turnips, strawberries, tobacco, clover, cotton, and many kinds of flowers. In some instances they have first attacked the weeds in a grain-field, and some kinds have taken a great liking to the open buds on peach trees in western New York

DESTRUCTIVENESS AND ABUNDANCE OF CUTWORMS.

From the earliest times, both in America and Europe, cutworms have ranked among the most destructive of insect pests. This is principally due to their unfortunate habit of cutting off the young plants and thus destroying much more than they consume. They are justly a terror to the agriculturist from the secrecy of their depredations and the extreme difficulty of arresting them. Every year hundreds of acres of corn have to be replanted and thousands of garden plants are cut off in nearly every State. In 1885 and 1886, the onion crop of Orange county, N. Y., estimated at 500,000 bushels yearly and worth half a million dollars, was reduced one-half by the attacks of a single species of cutworm. In 1893, cutworms destroyed nearly every green shoot of clover (second crop) that appeared over an area of about eight acres here on the University farm. During the past five years, hundreds of young peach trees have been killed by cutworms in the counties of Wayne and Monroe, N. Y. Many other equally as striking instances might be given of the destructiveness of these pests.

As is the case with other insects, cutworms have their years of unusual abundance. In several instances species, that have never before been known as injurious, have appeared in phenomenal numbers in certain parts of the country.

During the attack upon onions in Orange county, mentioned above, it was "common for a family to pick 10 or 12 quarts by day and the same number at night by the light of lamps." Sixty cutworms have been taken from a single hill of corn; and from fifty to a hundred are frequently found the same day on or around a single two or three-year old peach tree in western New York.

THEIR LIFE HISTORY.

As our knowledge of cutworms increases, the more difficult it is to record their life history in a general statement. There is found to be a great diversity in the life periods of the different stages, in the method of wintering, and in egg-laying habits, so that each species should be discussed separately.

The parent moths of many of the species appear during June, July and August.

But little is definitely known of the egg-laying habits of the moths. The eggs of some species have been found on the leaves of fruit and forest trees; one species has been reared on currant from eggs found on one of the leaves, while one common species lays its eggs on the trunk or twigs of fruit trees. Professor J. B. Smith says that they are also "laid on grasses, thrust close to the stalk under one of the sheath-leaves, and occasionally on stones. A single moth will usually lay from two hundred to five hundred eggs."* It is supposed that the young cutworms which hatch from eggs laid on the leaves or bark of trees feed on the leaves of the tree for only a short time, if at all, and soon drop or crawl to the grasses or other low vegetation below.

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*A female of *Rhynchagrotis crenulata* laid 1,027 eggs, as recorded in Bull. 22, U. S. Div. of Ent., p. 89.

In some cases the eggs are laid in midsummer, and the cutworms hatching therefrom become about half-grown before winter and hibernate in that stage in sheltered places or in the soil. One species (*carneades ochrogaster*) may hibernate in the egg stage while others lay their eggs in the spring.

When full-grown, cutworms bury themselves in the soil and by twisting the body about they form an oval, smooth cell within which they change to dark brown conical pupæ. From these pupæ the moths emerge later.

Probably most of the species of cutworms pass the winter as half-grown caterpillars. Some species winter as pupæ, and others in the egg stage; while in one case (*Agrotis ypsilon*), the indications are that the moth may hibernate, and egg-laying take place early in the spring. Some of the species pass through two generations in the course of a year, but in most cases there is only one generation.

NATURAL ENEMIES.

Cutworms have many enemies, both predaceous and parasitic, which often do good service as natural checks to their increase.

Predaceous.— Several birds, as chickens, the robin, the cat-bird, the red-winged black-bird and the purple grackle often include cut worms in their daily menu. Toads should be given free range in gardens, for, from the stomach of one of them, thirty-three cutworms have been taken. Spiders and mites are known to prey upon cutworms. They also have many enemies among their own-kind — the insects. Several of the ground-beetles (*Carabidæ*), in both their adult and larval stages, wage incessant war upon them.* Wasps and ants sometimes help in this warfare; and the spined soldier-bug often stabs them with its formidable beak and sucks out their juices.

Parasitic.— Cutworms have many parasitic foes among the insects. Probably the most efficient of these are the tachina-flies; these are allied to and resemble the common house-fly. They dexterously fasten their white eggs to the skin of their helpless victims, usually on the back near the head. Grubs soon hatch from these eggs and bore their way into the host, where they live upon the juices and fatty tissues, carefully avoiding the vital organs, until fully grown; they then leave their dead or dying victim and burrow into the soil, where they transform into the flies. At least 90 per cent. of the cutworms that ravaged the clover-field, mentioned above, were killed by one of these tachina-flies. It was difficult to find a cutworm that did not bear its quota of eggs, in fact, not enough could be found to enable us to breed the moth. Although most of the damage had been done for the season before the worms began to die from the work of the parasites, yet by their final death the next year's crop of cutworms was nearly annihilated over that area. Other similar instances of the efficiency of these tachina-flies in checking these pests have been recorded.

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* Dr. Fitch gives a graphic account of a ground-beetle "murdering a cutworm" in his Ninth Report on the Insects of New York, p. 817.

Cutworms also have several other smaller parasitic foes among the ichneumon-flies.

METHODS OF COMBATING CUTWORMS.

In order to include the methods adapted to all conditions the discussion of this topic is deferred until after the following account of some cutworms with climbing habits.

II. CLIMBING CUTWORMS.

Climbing cutworms are cutworms that, under certain conditions, assume climbing habits which enable them to feed upon the buds and leaves of shrubs, grape-vines, tall flowering-plants, etc.

THEIR HISTORY.

The European literature of the past sixty-five years contains several accounts of cutworms climbing grape-vines and doing much damage to the buds and leaves; a few species are recorded as climbing shrubs, but none seem to have been noticed on trees.

Apparently the earliest reference to climbing cutworms in America is found in the *Massachusetts Ploughman* for June 28, 1851; naked caterpillars came out of the ground in the night, and crawling up the the trunks of the fruit-trees, devoured the leaves, and returned to conceal themselves in the ground before morning. In 1852, Dr. Harris found the yellow-headed cutworm cutting off the tender shoots of roses, currant-bushes and other shrubs, and even young trees. In 1866, Dr. Riley gave a detailed account of the operations of three different species on the buds of fruit-trees, grape-vines, etc., in Illinois. The same year a climbing cutworm also injured grape-vines in California. The pests were especially destructive during the next two or three years in Illinois, Missouri, Indiana, Wisconsin and Michigan. Almost every year since, their depredations have been noticed in various widely separated localities and on a great variety of plants.

During the last few years they have appeared in unusual numbers in the peach orchards in the sandy regions of Michigan and New York. In 1894, one Michigan fruit-grower killed 1500 cutworms on some of his trees; one tree yielded 412 one night, 114 the next night, and 141 the next. His orchard produced only about half a crop of fruit.

FAVORABLE CONDITIONS FOR CLIMBING CUTWORMS.

Probably no cutworms assume the climbing habit when there are plenty of low-growing grasses and weeds at hand. Trees in grass or clover are rarely attacked by them, while those in fields kept free from other vegetation by cultivation always suffer the most, as the worms have to either climb or starve. It is found that if grain or some other cultivated crop be grown between the trees, the cutworms usually turn their attention to the trees only after the crop has been removed.

All cutworms prefer light, loose soils; climbing cutworms have done the most damage on plants growing in such soils. The light, warm, sandy soils in which are set many of the peach orchards of Michigan and New York are ideal places for these pests, and here their most destructive work is now being done.

Thus light, loose soils and a scarcity of low-growing succulent vegetation are conditions that may easily induce cutworms to assume the climbing habit.

THEIR FOOD-PLANTS.

Where clean cultivation is thoroughly practiced, thus leaving no alternative but to climb or starve, cutworms will climb almost any plant, even to the tops of high trees. The young cotton-wood, box-elder, maple, birch, and ash trees on the tree plantations in the west are often attacked. In Missouri in 1886, the grass under oaks, elms, and other shade trees was often thickly strewn with leaves and buds severed by cutworms; fruit-trees, as the apple, pear, and cherry, and a variety of vines and shrubs suffered in a similar manner. They have also attacked willow, catalpa, black-walnut, horse-chestnut, and negundo trees. Among fruit-trees the peach has suffered the most, as it is grown most extensively on the sandy soils where cutworms flourish best; standard varieties of fruit-trees are often injured as much as the dwarfs. Blackberry, raspberry, rose, and currant bushes must also be included in the list of food-plants. The buds and leaves of grape-vines, whether in California, New York, or Europe, seem to be favorite delicacies for cutworms.

Florists also have occasion to complain of these nocturnal marauders. Sometimes the buds, leaves, or flowers of out-door flowering plants are found strewn about on the ground in the morning; or a much admired blossom may have been eaten into and ruined during the night. The culprits, lying snugly hidden in the soil near by, are entirely unconcerned over the florist's discomfiture, and, unless their day-dreams are seriously interrupted, the destructive work is continued at night-fall. Often the young cutworms are unwittingly brought into the greenhouse with potted plants or in new soil in the fall. The worms may feed for a time unnoticed on the lower leaves or young shoots. A little later, or about the time the choicest blossoms or the smilax are at their best, or the tomato-vines that are being forced promise a good crop, then the nearly full-grown cutworms often do much damage. Many choice chrysanthemum and carnation blossoms have been mysteriously ruined in a single night. One chrysanthemum grower, not suspecting it was the work of cutworms, vainly tried to catch the culprits with mouse-traps!

CUTWORMS KNOWN TO HAVE CLIMBING HABITS.

Under the favorable conditions, discussed above, doubtless any species of cutworm would assume the climbing habit. A search through the American literature shows that at least ten different species have had occasion to climb for their food; our observations increase the number to an even dozen. In the list which follows is given the common name of the cutworm, the scientific name of each species, and the references to the first accounts of their climbing habits.

1852. Harris, Injurious Insects, p. 349.

The yellow-headed cutworm (*Xylophasia arctica* Bdv.).

1866. Riley, Prairie Farmer, June 2.

1869. Riley, First Missouri Report, p. 69–79.

The variegated cutworm (*Peridroma saucia* Hbn.).

The dark-sided cutworm (*Carneades messoria* Harr.).
The white cutworm (*Carneades scandens* Riley).
The well-marked cutworm (*Noctua clandestina* Harr.).
1884. Cook, Rept. Mich. Bd. Agr., 422.
The black-lined cutworm (*Noctua fennica* Tausch.).
1887. Murtfeldt, Bull. 13, U. S. Ent. Div., p. 60.
The mottled-grey cutworm (*Rhynchagrotis alternata* Grt.).
The white-spotted cutworm (*Homohadena badistriga* Grt.).
1894. Davis, An. Rept. Michigan Expt. Station, p. 89.
The speckled cutworm (*Mamestra subjuncta* Grt. & Rob.).
1895. Davis, Paper before Ass. Ec. Ent., Aug. 28.
The red cutworm (*Rhynchagrotis placida* Grt.).

Our observations in western New York, as detailed in this bulletin, add two more species to this list:

The dingy cutworm (*Feltia subgothica* Haw.).
The spotted-legged cutworm (*Porosagrotis vetusta* Wlk.).

All of the species are widely distributed in Canada and the northern half of the United States; and doubtless all occur in our State. The species that have usually been the most numerous during outbreaks of climbing cutworms are the variegated cutworm, the dark-sided cutworm, the white cutworm, and the speckled cutworm. The two latter have done the most damage in the peach orchards of Michigan and New York during the past two years; in Michigan, while *C. scandens* is present, nine-tenths of the cutworms are *M. subjuncta*, while in New York, 90 per cent. are *C. scandens* and *M. subjuncta* seems not to occur.

GENERAL NOTES ON THEIR DEPREDATIONS IN WESTERN NEW YORK.

During the past few years, thousands of peach trees have been set in the strips of warm sandy soils that abound along the shore of Lake Ontario. In 1893, complaints reached us from two localities (Rose, Wayne county, and Forest Lawn, Monroe county) that hundreds of these young trees, and grape-vines also, were being killed by something that ate into and destroyed the growing buds in the spring. Specimens of the culprits were soon obtained and they proved to be cutworms. Their appearance in this role was of unusual interest, for they were doing much damage, and there were no records of our New York cutworms having heretofore troubled the fruit growers by assuming the climbing habit.

However, it was then too late to institute experiments against the pests, as most of the damage had been done for the season and they were preparing to undergo their transformations to the adult stage — the moth. But many of them were gathered for us by correspondents and were turned loose in cages here at the insectary to breed. We were thus enabled in 1893 to learn considerable about their habits and life-periods that proved of value in the work the next year.

In the latter part of April, in 1894, soon after the cutworms had begun operations, we visited Forest Lawn for the purpose of making additional observations, to gain further information in regard to what had been done to prevent their depredations, and to test some new methods which seemed practicable. Much interesting and valuable information was thus obtained. Forest Lawn was reached about 8:15 P. M., or just in time to watch the pests as they began operations for the night. By the aid of a lantern, many were seen crawling out of the sand around the base of the trees and making their way up the trunk and out onto the branches where they soon began their destructive work on the opening buds; the frontispiece illustrates this point. Most of them are at work by 10 P. M., and many continue to work until nearly daylight. Probably most of them leave the trees by dropping to the ground instead of crawling back the way they came. Upon reaching the ground they bury themselves in the sand about an inch below the surface and usually within a radius of a foot from the base of the tree. No distinction seems to be made between fruit and leaf buds. Fifty have been found at one time on a tree set the preceding year, and 120 on two or three-year old trees.

For several years, previous to 1893, many peach growers in the neighborhood had noticed that the buds did not start on some of their young trees, and often many of these trees soon died, as they supposed, from the effects of frost or other unknown causes. One extensive grower told us the curious way in which he at last discovered the real culprits. He happened to be passing through his recently-set orchard on a still night, and heard a distinct nipping sound which seemed to proceed from the trees. Investigation showed that the noise was caused by the coming together of hundreds of the minute horny jaws of cutworms on the peach buds.

One cutworm doubtless destroys several buds in a night and thus a few worms soon kill young trees, or by eating the buds from a few main branches so distort and stunt their growth as to render the tree very unsymmetrical and often of little value. Last spring one fruit grower at Forest Lawn, N. Y., had nearly all of his recently-set peach trees killed in one night by the cutworms. When there are not buds enough to go around, some of the worms gnaw off the bark on the branches, often girdling them; in one orchard where they were prevented from getting to the buds, they ate off large patches of the bark on the trunks of the trees. They usually begin operations in the spring soon after the buds begin to swell. Those found at work on April 27th, were of different sizes, ranging from half grown to nearly full-grown. Their most destructive work was done on the opening buds of young trees in April and May; some of the worms continued to feed upon the foliage during June. In June, one grower, "found green peach leaves sticking into the sand and on digging found the cutworm at the lower end." Peach trees of all sizes, ages, and varieties were attacked indiscriminately, but the cutworms were not so numerous as to produce noticeable injury on large bearing trees in but few instances. Trees more than three years from the bud were rarely killed, but younger trees were often set back from one to two years' growth. Grape-vines, berry-bushes, and all kinds of crops grown on the sandy soils also suffered much injury from the same species of cutworms.

It was especially noticeable that the cutworms did the most damage on trees and other plants set in the sandy soils. Orchards a few rods away on heavier soils suffered comparatively little. So loose is the sandy soil in many of these peach orchards that it is often drifted by the winds; these are ideal places for peach trees and unfortunately for cutworms also. Such soils are easily kept free from weeds and grass and the cutworms are thus driven to the trees for food. One grower noted that the trees he set in a meadow were not disturbed, and those in cultivated ground next to a meadow were but slightly damaged.

In 1894, we saw in operation several methods for combating the pests, and we tested others. The different methods are discussed in detail on page 670.

Our observations and breeding experiments show that there are at least four different kinds of cutworms engaged in climbing peach trees in Wayne and Monroe counties. A detailed, illustrated account of the lives of each of these species will now be given; it seems best to also include in this discussion a fifth climbing species, which we have investigated as a greenhouse pest.

1. The White Cutworm.

Carneades scandens Riley.

This species constituted over 90 per cent. of the cutworms that climbed peach trees in western New York in 1893 and 1894; this statement is based on the examination of nearly 700 specimens *taken from the trees* in Wayne and Monroe counties.

Its history and distribution.—This cutworm was first described from Illinois in 1866 by Dr. Riley (Prairie Farmer for June 2); three years later he described the adult insect—the moth—as a new species (First Missouri Report, p. 78). During these three years the cutworm had done much damage to the buds of fruit trees and grape-vines in Wisconsin, Illinois, Missouri, Indiana and Michigan. It was, apparently, the most numerous of the climbing species in these localities. The insect seems not to have again attracted notice as an injurious species until 1886. Miss Murtfeldt then recognized it as one of the species at work on the buds of shade and fruit trees in Missouri. In 1888 it was abundant, and injurious to apple buds in Canada; the moth had been known in Canada for several years. In 1894 it was identified as one of the cutworms so destructive in Michigan peach orchards.

The first record we have of the insect in our State is in 1873, when Dr. Lintner collected the moth at Schenectady; it was taken in Erie county in 1875, and at Fenton, Lewis county, in 1877.

The species is now known to occur in Colorado and most of the northern States east of the Rocky mountains, and in Canada. It is thus an American insect and has a wide range. It is one of the most common and injurious of the cutworms with climbing habits.

Its appearance.—The full-grown cutworm measures about one and three-fourths inches in length; it is shown about natural size in the frontispiece, and twice natural size at *l* on plate 1. Its general color is a very light yellowish-gray, with irregular whitish areas on the dorsal and lateral aspects of the body; these merge into quite a distinct white stripe just below the spiracles. The head and the horny thoracic and anal shields vary considerably in color in different specimens, but are usually light brown, mottled or dotted with black; in young caterpillars the head is sometimes almost black. The spiracles are black, and thus contrast very sharply with the whitish body color, as shown in the figures. Short, brownish hairs arise from small blackish-green spots regularly arranged on the body; the dorsal spots are darker. Its general whitish color and indistinct markings render it easily distinguished from most cutworms.

The adult insect is shown natural size at *a*, plate 1, and twice natural size at *b*. Its front wings vary considerably in their ground color; they are ash-grey, suffused with either yellowish, brownish or reddish. The hind wings are whitish, with a double dusky shade on the outer edge, and a dark discal spot. The indistinct markings on the front wings are well shown in the figures.

Its habits.—This cutworm has always been reported as a climber; but several of our correspondents were very sure that they recognized it among the culprits that cut off their cabbage and other garden plants grown in sandy soils in the neighborhood of the injured peach trees. Its climbing habits have been described in detail on a preceding page in the general notes on their depredations in western New York.

The moths, doubtless, feed on the nectar of flowers as do other Noctuids. They are attracted to lights and to sugar baits.

Its name.—Usually the adult and caterpillar stages of the insects known as "cutworms" are given different popular names. The cutworm under discussion was named by Dr. Riley "the climbing cutworm." He named the moth "the climbing rustic," and by these names the insect has since been known. As the scientific name of the insect, *scandens*, means to climb, it may be well to not change the popular name of the moth. But there are now several other cutworms equally as common, and in which the climbing propensity seems equally as well developed whenever occasion requires; it thus seems inappropriate to designate this cutworm as *the* climbing cutworm. As cutworms are usually named from some peculiarity of their coloration, and as this one is nearly white in color and all its markings are white, we propose the more appropriate name of "white cutworm" for it.

Its life-history.—Practically nothing has been added to our knowledge of the life-history of this insect since Dr. Riley's account in 1869. He found different sizes of the cutworms appearing on the buds during the last week of April in Illinois. In confinement they were fed on apple and grape leaves, and began entering the ground for pupation May 20th. Nine days later the moths began to appear in his cages, and the last one issued June 29th. We found different sized, from one-half to nearly fullgrown, cutworms at work on the trees in western New York on April 27th, but did not succeed in rearing the moths before June 27th; some did not emerge until July 21st. They did not breed readily in our cages, containing young peach shoots, as only eight moths were obtained from over a hundred cutworms. Our observations indicate that the cutworm form an oval cell about two inches below the surface of the soil and in about a week changes to a brown pupa; it seems to remain in the pupa state at least a week.

Dr. Lintner has collected the moths in this State on July 8th and August 30th. In 1886, Mr. H. S. Saunders collected nearly every night at electric lights in London, Canada, from May 22d to November 2d, and found this moth common on June 15th, and 19th. It is thus probable that most of them emerge from June 15th to July 15th in our State. There seems to be but one brood in the course of a year.

Nothing is definitely known of the life of this insect from the time the moth emerges until the next spring. It is probable that the eggs are mostly laid in July, and quite possibly on the leaves or bark of the trees. They must hatch in time to allow the young cutworms to attain half or two-thirds their growth before winter sets in. As the moths emerge over so long a period, some eggs are laid quite late in summer and thus the cutworms must vary considerably in size when they go into winter quarters buried in the soil. They appear above ground as soon as growth begins in the spring with their appetites whetted by the long winter's fast.

2. THE SPOTTED-LEGGED CUTWORM.

Porosagrotis vetusta Walker.*

Less than 2 per cent. of the climbing cutworms received from western New York in 1893 and 1894 belonged to this species.

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* SYNONOMY.

Mythimna vetusta. 1856. Walker, Cat. Brit. Mus., ix, 78.
Agrotis muraenula. 1868. Grote and Robinson, Trans. Am. Ent. Soc., i, 352,
Porosagrotis vetusta. 1893. Smith, Bull. 44, U. S. Nat. Mus., p. 85.

Mr. Grote and Prof. Smith, both recognized authorities in our systematic knowledge of the North American Noctuids, are not agreed as to the name of this insect. Mr. Grote has criticised (Can. Ent., xxvi, p. 81) Prof. Smith's relegation of *muraenula* into the synonomy of Walker's *vetuesta.* Our reasons for adopting Prof. Smith's views are given in detail in the *Canadian Entomologist* for November, 1895.

The insect is of especial interest, however, for the caterpillar or cutworm has never before been identified, although the moth has been known for nearly forty years.

Its history and distribution.—It is an American insect, but the moth was first described in England from specimens taken in Nova Scotia. It is now known to occur in Canada and in the United States west of Colorado and south of Georgia. In 1875, it was captured in Erie and Lewis counties in our State. The cutworm has never appeared in sufficient numbers to do noticeable injury.

Its appearance.—The cutworm, shown twice natural size at *l*, Plate 2, is about one and a half inches in length, with its whole dorsal surface above the spiracles of a dull, dark greyish-brown color; it is considerably lighter on the venter. The greenish-black piliferous spots are very distinct all over the body; the lateral ones are considerably larger, as shown in the figure. The spiracles are black. The head and the thoracic and anal shields are brown with black mottlings. The caudal aspect of the base of the true legs and the cephalic aspect of the pro-legs are of a dark greenish-black color; these dark spots render this cutworm easily distinguishable from the white cutworm.

The moth is shown natural size at *m* on Plate 2, and twice natural size at *mm*. The front wings and dorsum of the thorax are of an ecru-drab or ash-grey color and marked with small triangular black and white spots as shown in the figures. The hind wings are nearly clear white.

Its habits.—This cutworm was found feeding at night, in company with the white cutworm, on peach buds in western New York. Further than this nothing is yet known of its habits.

The moth is attracted to lights and to sugar baits. Prof. J. B. Smith says he has "taken it on goldenrod in September during the day."

Its name.—No popular name has yet been proposed for this Noctuid. The characteristic spots on the legs of the caterpillar suggested to us the name, "spotted-legged cutworm," with which we have christened it.

Its life-history.—Nearly full-grown cutworms were received from Monroe county early in May. One of them changed to a pupa July 23d on the surface of the soil in our cage. The moth did not emerge until August 17th. The moths have been captured in Massachusetts in August and September, and in New York in July and on August 21st and 25th. Nothing further is known of its life-history; it probably differs but little from that of the white cutworm just discussed, that is, there is doubtless but one brood during a year and it winters as a half or two-thirds-grown cutworm.

3. THE WELL-MARKED CUTWORM.

Noctua clandestina Harris.

Nearly 5 per cent. of the cutworms taken on peach trees at Forest Lawn and sent us in 1894 were this well-marked cutworm; it was not present among the specimens received in 1893.

Its history and distribution.—This very common Noctuid was described and named by Dr. Harris in 1841 from specimens bred by himself and from one sent him by Dr. Melsheimer, who had bred it in Pennsylvania from a cutworm working in corn. The cutworm was not definitely described until 1869 (First Missouri Report, p. 79) when its climbing habits were first recorded by Dr. Riley. The species is frequently mentioned in accounts of cutworm depredations, but has rarely appeared in any locality in large numbers; it was unusually common in Illinois in 1887.

It has a wide distribution. Dr. Fitch recorded it as very common in our State in 1856. In 1875 it was reported from California and Nevada. It is now known to occur all over the United States, except in the Southern States, and in Canada, including Manitoba.

Its appearance.—The two figures of the cutworm, twice natural size, on plate 3 well show its characteristic markings. It is of a greenish-ash color mottled with dusky, and distinctly marked with four rows of conspicuous, more or less triangular, black spots arranged as shown in the figures; the spiracles are situated in the spots of the lateral rows, and are bordered below by yellowish patches. The narrow light stripes seen in the figures are yellow. The head is yellowish, recticulated with brown and marked with a wide brown band on each side of the middle.

The moth is shown natural size at *a*, and twice natural size at *b* on plate 3; the figures represent nearly its natural coloring. Its front wings are of a dark smoky brown color with rather indistinct markings. The female has a curious and apparently unique structure on each side of the venter of the next to the last abdominal segment; it is a deep smooth depression whose object is not known.

Its habits and food-plants.—Mr. Gillette says (Iowa Exp. Sta. Bull. 12, p. 541) this cutworm is the typical climbing species in Iowa, and he has taken them in large numbers from the trunks of box-elder, and in less numbers from apple and soft maple. However, the species is usually among the culprits that cut off corn and other garden crops. It frequently drags its food into its day-retreat where it continues to feed upon it. Dr. Riley has recorded it as quite often found climbing low bushes like currants, and as occurring "abundantly on a species of wild endive under the broad leaves of which it frequently nestled during the day, without entering the ground." It is common in grass lands and in grain fields.

When at rest the moth folds its wings so closely and flatly over its back that it is enabled to get into very narrow crevices. Hence it usually lies hidden during the day "under the bark of trees, in the chinks of fences, and even under loose clapboards of buildings. When the blinds of our houses are opened in the morning, a little swarm of these insects which had crept behind them for concealment is sometimes exposed and suddenly aroused from their daily slumber (Harris)." They fly freely to lights and sugar baits at night from June until September.

Its name.—On account of its noticeable habit of concealing itself during the day in all sorts of unsuspected places Dr. Harris very appropriately named the moth *clandestina*—the clandestine owlet-moth. The caterpillar or cutworm was named the "w-marked cutworm" by Dr. Riley, who thought he saw a resemblance to a series of the letter w in the arrangement of the black spots as he looked along the dorsum toward the head. In all of the specimens we have seen, it requires too great a stretch of imagination to see this w-mark; Prof. Forbes also failed to find it in making his excellent description of this cutworm (Fifth Report, p. 55). Therefore, in spite of the fact that this name — w-marked cutworm — has been in current use for a quarter of a century, we believe it best to change the name slightly and call it the "well-marked cutworm;" this only adds three letters to the old name, and makes it better express a conspicuous characteristic of the cutworm.

Its life-history.—We can add but little to the original account of the life of this cutworm by Dr. Melsheimer in a letter to Dr. Harris in 1841. He said: "When first disclosed from the eggs they subsist on the various grasses. They descend in the ground on the approach of frosts, and reappear in the spring about half-grown, Their transformation to pupæ occurs at different periods, sometimes earlier, sometimes later, according to the forwardness of the season, but usually not much later than the middle of July." Dr. Harris added that the moths are very abundant in New England from June 15th till the end of August.

There are many records of the capture of the moths at lights or at sugar baits. In Canada the dates of capture range from June 19th till October; in New York the dates are between June 15th and September 23d. In a series of six trap-lanterns kept lighted every night during the spring, summer, and fall of 1889, we captured in all 21 of the moths on the following dates: 1 on June 10th, 2 on June 15th, 2 on June 21st, 6 on June 25th, 6 on June 28th, 6 on July 2d, 1 on August 28th, and 1 on September 26th. Although the flight of the moths extends over so long a period there seems to be but one brood of the insect in the course of a year in this latitude.

The eggs are doubtless mostly laid in June and July and the cutworms hatching therefrom attain about half their growth before going into winter quarters. Prof. Forbes says most of the cutworms finish their growth in Illinois in April and early May. In 1871, Mr. Saunders found the half-grown cutworms under chips and logs in open fields in Canada early in May; these became full-grown by May 25th and one pupated the next day. From nearly full-grown specimens taken on peach trees April 29th we bred the moth on June 11th and 12th.

Thus there is yet much to be learned of the life-history of this well-marked cutworm.

4. THE DINGY CUTWORM.

Feltia subgothica Haworth.*

This is one of the most common cutworms in our State, and yet only 3 per cent. of the specimens found on peach trees in Monroe county in 1894 were this dingy cutworm. This indicates that it does not often assume the climbing habit, and so far as we can find, it has never before been recorded as a climber.

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* The scientific name of this insect has been the source of much discussion in recent years. Much of the confusion has resulted from the fact that it was first described in England from supposed English specimens. We have made a critical historical investigation of the systematic literature of the species, and have embodied the results in detail in an illustrated article in the Canadian Entomologist for November, 1895. At present, we believe, the evidence warrants the use of the above name for the insect; the generic name may have to be changed to *Agronoma* in accordance with the latest revision of the old and unwidely genus *Agrotis*.

Its history and distribution.— The moth was first named and described in England in 1810 from three or four American specimens that had become mixed with English insects; it was not until 1847 that the facts regarding the origin of most of these specimens was pointed out, and the name was soon dropped from British lists. A few English entomologists, however, still believe that the single specimen belonging to Haworth, the describer, was a variety of a common English species, but there is little evidence to support such a view. In 1852, it was again described (as *jaculifera*) in France from several moths taken in America. It was first mentioned in American literature by Dr. Fitch in 1856; he said it was then much the most common Noctuid in our State. The same year it was again described in England (as *ducens*) from New York and west Canadian specimens.

The cutworm was first described and figured by Dr. Riley in 1869 from Illinois, where it was very destructive in gardens. It, doubtless, is one of the culprits in most of the reported outbreaks of cutworms, and yet it has been definitely identified as doing noticeable injury only a few times. In 1886 it was found destroying many ripening strawberries in Indiana, and in 1887 and 1888 it was very abundant and destructive in meadows and clover fields in Illinois. Canadian field and garden crops were ravaged by cutworms in 1888 and 1889, and the dingy cutworm was recognized as one of the most numerous and destructive species. In 1890 beans, squashes and cucumbers suffered severely from it in Michigan.

It is, thus, one of our most common owlet-moths, and is known to occur throughout the United States and in all of the Canadian provinces from the Atlantic to the Pacific coast. It is an American insect, and has thus far never spread beyond its own country.

Its appearance.—The excellent figures of the cutworm, twice natural size, on plate 4, well illustrate its characteristics. It has a very wide, buffy-grey dorsal stripe, and the sides are of a dusky, dingy grey; the venter is lighter. The head and the thoracic and anal shields are dark brown or dusky. The dark greenish-black piliferous spots just behind the spiracles are large and prominent. The spiracles are black; the anterior ones are situated in a large coriaceous brown spot.

Both sexes of the moth are shown natural size (at *m* and *f*), and twice natural size (at *mm* and *ff*) on plate 4. It is one of the most distinctly marked of the owlet-moths. The males are easily distinguished by their tufted abdomens and serrated antennæ. The ground color of the front wings is a smoky gray. The markings are well shown in nearly their natural colors in the figures; the reniform spot is yellowish.

Its habits and food plants.—This cutworm rarely assumes the climbing habit, and usually confines its depredations to cutting off garden plants or to working in grass or grain fields. Ripening strawberries, corn, wheat, sweet potatoes and beans are agreeable food for it. Prof. Cook says that during the outbreak in Michigan in 1890 he often saw some of them crawling on the top of the ground, even in the hot sunshine.

The moths usually lie concealed during the day in sheltered places, but they have been recorded as abundant on the flowers of thistle (*Cirsium arvense*) and on the unexpanded flowers of *Verbascum thapsus.* They are readily attracted to lights; in 1889 more specimens of this moth were taken in our trap-lantern experiment than of any other species of insect. Sugar baits also attract them in large numbers.*

Its name.—When the moth was first described in 1810 as *subgothica*, it was also given the popular name of "gothic dart;" the owlet-moths are often called the dart-moths in England, from the dart or spear-like streak which many of them have near the base of their front wings.

The cutworm was well designated as the "dingy cutworm" by Dr. Riley.

Its life-history.—Although this insect is so very common, and often very destructive, in many parts of the country, but little is known about its life. It winters as a young cutworm; in Illinois Prof. Forbes found specimens less than half an inch long on January 24th. By April 25th most of the cutworms he collected were from three-fourths to full grown. Preparations for pupation began May 18th, while a few continued to feed until June 9th, and others were found underground as late as July 19th. Thus, some of the cutworms work during a period of over two months in the spring. This naturally varies the time of pupation and causes the emergence of the moths to take place over quite a long period. When full grown the cutworms bury themselves in the soil from one to two inches, and in a few days change to pupæ in earthen cells. The pupæ stage seems to last for a longer period than usual among these insects. Cutworms received by Dr. Riley on June 27th changed to pupæ by July 7th, but the moths did not emerge until September 2d. In Prof. Forbes' experiments many had, doubtless, become pupæ by June 1st, and the moths emerged from August 19th to 30th. From nearly full-grown cutworms which we put in our cages from April 29th until May 15th, no moths were bred until August 18th. Thus, at least a month and a half of the summer seems to be passed as a pupa.

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*Dr. Packard once beheaded one of the moths "at 40 minutes past 9 in the evening. It was lively at the night of the fourth day, flying about when disturbed; but at 7 in the morning of the fifth day it was found nearly dead, slight movements of its feet and abdomen being perceptible (Psyche, ii, 18)."

The insect is very abundant here at Ithaca, N. Y., as is shown by the following table (p. 664), giving the number of specimens caught each night in our trap-lantern experiment during 1889 and 1892; other recorded captures are also included in the table. In 1889 we kept six lanterns lighted every night from May 1st till October 15th; in 1892 only one lantern was kept lighted for a similar period.

It will be seen that in 1889 the moth flew from July 12th till September 18th, and in 1892 from June 21st till September 30th, and yet there is nothing to indicate more than one brood. They appeared in the greatest numbers in 1889 from August 14th to September 6th, over 97 per cent. of them being taken during these three weeks. In 1892 the period was about the same, but began a little earlier. This agrees very well with the dates given among the other recorded captures. As the tables show, a great majority of the moths captured in the lanterns were males; this fact is of much practical importance, as will be seen when we come to discuss the trap-lantern method of fighting these insects.

Doubtless most of the eggs of this species are laid before September. Mr. Gillette found that many of the females had their abdomens filled with eggs on August 15th. In the latter part of August, 1891, we captured several females at lights and confined them in bottles with clover and plantain leaves. All but one of them died in a few days without laying eggs. By September 3d one had laid ten eggs on the clover leaves.* These eggs hatched on September 8th and 9th. The young cutworms were of a light drab color, with the brown piliferous spots quite distinct; the head and thoracic shield were brown. They were placed in stages containing clover, but we failed to rear them.

TRAP-LANTERNS AT ITHACA, N. Y.						OTHER RECORDED CAPTURES.		
1889. SIX LANTERNS.			1892. ONE LANTERN.					
Date.	Males.	Females.	Date.	Males.	Females.	PLACE	Dates.	Number.
July 4.	1	....	June 24.	9	3	N. Y. State.	1856. July to Sept.......	Common.
July 12.	1	....	July 15.	....	1	N. Y. State.	1872. July 21, 30.........	....
July 21.	2	....	July 25.	....	1	Ontario.....	1875. Aug. 9 to Sept....	Common.
July 23.	1	....	July 28.	1	....	N. Y. State.	1875. Aug. 2, 19, 21, 26...	....
July 26.	1	....	July 30.	1	....	N. Y. State.	1877. July 21............	Common.
July 27.	2	....	July 31.	3	....	Massach'ts..	1877. August............	Common.
July 28.	1	....	Aug. 1.	3	....	N. Y. State.	1878. Aug. 13, 18, 30.....	Common.
July 29.	6	....	Aug. 2.	4	1	Ohio........	1885. June 15............	Fifty specimens.
July 30.	2	2	Aug. 4.	4	....	Ontario.....	1886. August 24–30.	Common.
July 31.	12	2	Aug. 5.	12	....	Iowa	1889. July 2 to Sept. 20.	{ Common. Aug. 20 to Sept. 5.
Aug. 1	7	2	Aug. 6.	8	3			
Aug. 2.	19	....	Aug. 7.	2	....	Michigan...	1830. Aug. and Sept.....	Common.
Aug. 3.	9	1	Aug. 8.	3	....			
Aug. 4.	17	3	Aug. 10.	3	1			
Aug. 5.	39	4	Aug. 11.	3	....			
Aug. 6.	5	....	Aug. 12.	7	....			
Aug. 7.	3	....	Aug. 13.	4	....			
Aug. 8.	5	....	Aug. 14.	3	1			
Aug. 9.	32	1	Aug. 15.	7	1			
Aug. 10.	7	1	Aug. 16.	10	....			
Aug. 11.	9	2	Aug. 18.	10	....			
Aug. 12.	5	....	Aug. 19.	33	5			
Aug. 14.	30	3	Aug. 21.	16	....			
Aug. 15.	59	1	Aug. 22.	17	....			
Aug. 16.	42	....	Aug. 23.	17	2			
Aug. 17.	76	10	Aug. 25.	9	1			
Aug. 18.	124	3	Aug. 26.	9	1			
Aug. 19.	161	9	Aug. 27.	25	3			
Aug. 20.	198	6	Aug. 28.	4	2			
Aug. 21.	160	19	Aug. 29.	1	1			
Aug. 22.	108	6	Aug. 30.	4	1			
Aug. 23.	63	2	Aug. 31.	4	1			
Aug. 24.	122	10	Sept. 1.	6	....			
Aug. 25.	209	8	Sept. 2.	1	....			
Aug. 26.	110	7	Sept. 3.	1	....			
Aug. 27.	90	2	Sept. 5.	1	....			
Aug. 28.	93	3	Sept. 8.	1	....			
Aug. 29.	97	4	Sept. 11.	1	....			
Aug. 30.	53	2	Sept. 19.	....	1			
Aug. 31.	108	6	Sept. 25.	....	1			
Sept. 1.	60	8	Sept. 30.	1	....			
Sept. 2.	65	2						
Sept. 3.	50	....						
Sept. 4.	87	4						
Sept. 5.	23	....						
Sept. 6.	37	2						
Sept. 7.	8	....						
Sept. 8.	16	3						
Sept. 9.	1	....						
Sept. 11.	1	2						
Sept. 14.	1	....						
Sept. 16.	2	1						
Sept. 17.	1	....						
Sept. 18.	....	1						
Total..	2240	142	....	139	30	....	....	....

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* The following description of the egg was made at the time: Nearly spherical; height, .45 mm.; diameter, .57 mm. Color a dirty white, with brown mottlings. The surface is raised into numerous wavy ridges, which converge about a small roughened area, the micropyle, on the apex. The furrows between the ridges are crossed by numerous fine line-like ridges, which give the whole egg a reticulated appearance especially toward the apex.

The evidence seems to support the following brief summary of the life-history of this dingy cutworm so far as we now know it. It hibernates as a half-grown cutworm which feeds during April and May, usually becoming full-grown about July 1st when it changes to a pupa in the soil. Apparently about a month and a half is spent in the pupa state, and most of the moths emerge from August 10th to September 6th. The eggs soon hatch, and the young cutworms attain about half their growth before they go into winter quarters. There is but one generation during the course of a year in this latitude.

5. THE VARIEGATED CUTWORM.

Peridroma saucia Hubner.

This cutworm seems not to have been among those engaged in the destructive work on the peach buds in western New York, but several times we have been called upon to investigate it as a climbing cutworm in greenhouses; it may thus be appropriately discussed in this bulletin.

Its history and distribution.—It is probably an European insect. The moth was described and figured in 1790 in France* but was not given a scientific name until 1816 in Germany. Eleven years later the cutworm was first known, and it is now not uncommon throughout Europe. In 1852, the moth was recorded from South America, and in 1859 the cutworm ravaged the tobacco plantations of Algiers in northern Africa. The insect also occurs in Asia and in the Canary and Madeira Islands.

Its history in this country began in 1841 when Dr. Harris bred the moth from some cutworms found in his garden. It is now widely distributed throughout the United States and the Canadian provinces, and is regarded as one of the most common and destructive cutworms we have. Almost every year during the past fifteen years it has been reported as doing serious damage in grass or grain fields, in gardens, in greenhouses, or by climbing grapevines and fruit or shade trees.

It is nearly a cosmopolitan insect, but is apparently most numerous and destructive in the United States and Canada; it is rarely mentioned in European economic literature.

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*Ernst and Engrammelle. Papillons d'Europe, vol. vii., p. 65, pl. 278, fig. 455. It was called "La Rubiconde."

Its appearance.—The full-grown cutworm, shown about twice natural size on plate 5, is of a sooty-brown color finely mottled with gray, slightly darker on the back; there is a small yellow spot on the middle of each of several central segments, and a dark patch on the segment before the last. A conspicuous yellow stripe, mottled with red on its upper edges, extends along each side just below the spiracles. Dark, sooty, longitudinal marks occur along the subdorsal region, and also along the body near the spiracles. The head is reddish-yellow, reticulated with rufous. On Segment ten the sooty dorsal spots form an indistinct w.

As is shown at *c*, natural size, and at *d*, twice natural size, the moth is very indistinctly marked; the markings are often only obscure shadings. The front wings are of a yellowish or purplish brown, more or less suffused with black and gray. The hind wings are shown in nearly their natural colors in the figures.

Its habits and food plants. In Europe, this cutworm is recorded as feeding on common chickweed, plantain, and *Rumex acutus*.

In this country it usually feeds on low-growing plants, but has several times assumed climbing habits. In confinement it has been fed upon knot grass, corn, grass, tips of grape-vines, apples, willow, eupatorium, white mulberry, plantain, the leaves of soft maple, box-elder, elm, apple, cherry, strawberry, currant, peach, raspberry, rose, and purslane, etc. It attacks almost any field crop, and weeds even are eaten with evident relish when no more succulent food is at hand.

It seems to occur more frequently in cold-frames and greenhouses than other cutworms. In 1869, Dr. Riley found it doing considerable damage to a lot of young grape-vines in a cold-frame; it has also been quite destructive to lettuce grown in similar situations. In 1880, they were found climbing smilax in a greenhouse at Lowell, Mass., and were again reported destroying smilax in 1882 from Germantown, Pa. In 1893, a correspondent in Kalamazoo, Mich., sent us specimens of this cutworm which he said had nearly destroyed his smilax; they climbed up the strings to the top and ate all the leaves. Thus, smilax seems to be a favorite food for them in greenhouses. Several instances have been recorded of carnations being attacked in greenhouses by this cutworm. They climb up and eat into the buds; in one instance nearly 500 buds were thus destroyed in less than a month. The source of infection in one case "was clearly traced to earth taken in the fall from beneath the sod in a pasture field which was badly infected with cutworms;" doubtless, in most cases, this is the way the young cutworms are introduced into greenhouses. In 1893, a correspondent in Bolivar, N. Y., wrote us that nearly 100 fruits on his tomato plants in his greenhouse had been badly damaged by cutworms; they preferred the fruit to the leaves. From specimens sent we bred the moth of this variegated cutworm.

In November, 1890, something began eating the chrysanthemum blossoms here in the University conservatory. The florist thought it the work of mice, and traps were accordingly set. After two or three nights spent in fruitless attempts to check the depredations of the culprits in this way, it was discovered that it was the work of this cutworm. It would climb up the flower stalks in the evening and, upon reaching the blossom, would firmly grasp the stalk just below with its pro-legs, and then reach out as far as possible onto the petals and eat them down to the base; the outer portion of the petals, which they could not reach, usually dropped to the ground, often to be eaten by cutworms just coming from their day-retreats. One cutworm would thus quickly damage these beautful blossoms, and frequently two or three of them would completely destroy a whole blossom in a single night. It was found they had been feeding on the young shoots before the blossoms opened.

In one instance this cutworm climbed cabbage stalks and bored in various directions through the forming heads, and were found coiled up in the moist places they had eaten out for themselves.

In 1886, it assumed the climbing habit in Missouri with very serious results to the buds of fruit and shade-trees. In 1888, it damaged grafts and ate off the tips of fruit trees in British Columbia, and it also committed serious depredations the same year in Arkansas by devouring the foliage of potato vines. In California it has twice appeared in very destructive numbers on the grape vine, once in the spring of 1893 and again in 1895; in some cases the vines were entirely defoliated and the young shoots cut off.

The above accounts of the depredations of this variegated cutworm show that its varied habits render it a very serious pest, as it may cut off field and garden crops, or it may appear as a climber on the choicest greenhouse plants or out of doors on fruit-trees and especially in vineyards.

The moth, like all owlet-moths, is nocturnal in habit and is readily attracted to lights. They feign death when disturbed and can thus be readily captured. When alarmed they first seek flight by running, rather than by flying.

Its name. — Although this owlet-moth was named "the rubicund" in 1790, its scientific name—*saucia*—dates from 1816. It seems to have no popular name in Europe except in England where it has been called the "pearly underwing." In this country it is known as the "unarmed rustic" moth, a name given it by Dr. Harris in 1841, because it lacked the common lance-shaped spot on the fore wings.

In 1869, Dr. Riley named the caterpillar "the variegated cutworm." It seems to have no common name in other countries.

Its life-history.—More is known of the life of this cutworm than of most others, and yet our knowledge is far from complete. In Europe, but little has been added to Schmidt's account of its life as published by Freyer about 1830. The cutworms were found late in the fall under plantain and *Rumex acutus*, and changed to pupæ in the earth before winter; the moths emerged early in the spring, and there was doubltess a second generation, for Mr. Schmidt found some eggs in March on a dry plantain leaf and bred the moths from them. In England in 1867 (Ent. Month. Mag. iv. 119, 134) eggs were obtained from females taken in September and October; these hatched in from three to five days, and pupæ were formed in December. From cutworms taken in July or August, the moths were bred in September and October. The conclusions were that the insect hibernated in the pupa state and was two brooded, one brood being on the wing in May and June and the other in August, September and October.

In this country considerable more has been learned of its life. The eggs, shown natural size at *b* and enlarged at *a* on plate 5, have been found in April and May in regularly arranged elongate patches of about 500 each. They are round and of a pink color with about forty prominent longitudinal ridges connected somewhat irregularly with numerous transverse lines; just before hatching they change to a lavender color. These patches of eggs have been found on the bark of the twigs, trunks, and branches of young apple, pear, and peach trees, on the trunk of plum and mulberry trees, on the twigs of bur-oak, on grape-vines, and on the leaves of mulberry. They were first identified by Dr. Riley in 1869.

The eggs are probably laid in the spring, but the duration of this stage is not known. Some have hatched as early as April 9th, and others not until May 24th. The newly-hatched cutworms are of a dirty yellowish-green color with a black head and very distinct piliferous spots. Their first food consists of the delicate pink egg-shells from which they have just emerged. For a while they live, for the most part, in company on the leaves of the plant bearing the eggs, and they do not hide during the day. In this stage they move about with a looping gait like the well-known measuring-worms.* After the first shedding of their skin, which takes place in about a week, the characteristic markings of the variegated cutworm begin to appear, and they drop from the trees and assume the normal cutworm habits.

They shed their skins three times more at intervals of three or four days; each stage has been carefully described by Dr. Lintner (Fifth Report, 202–203). In his experiments, the cutworms were from 23 to 28 days in attaining their full growth; this agrees very closely with Dr. Riley's observations. The mature cutworm goes into the soil a short distance and there twists about and forms an earthen cell in which it changes to a pupa in two or three days. Dr. Lintner's specimens began changing to pupæ June 5th, and Dr. Riley's on June 17th. Moths from the former pupæ emerged about June 25th, and from the latter on June 28th to July 5th. This, and other records, indicate that the pupa state lasts from 11 to 20 days in June. All the breeding experiments (thus far recorded) show that in the spring it requires from 35 to 62 days for the insect to undergo its transformations from the hatching of the egg to the emergence of the moth; most of the records are about 47 days.

Prof. Forbes states that the spring brood of cutworms may feed in Illinois "until the first of June, sometimes pupating, however, by the middle of May, and sometimes not entering the earth until the middle of June." The moths began to emerge in his breeding cages June 14th, but they were not abundant abroad until about

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*Dr. Lintner and Dr. Riley differ in their statements regarding the number of pro-legs which these newly-hatched cutworms have. Dr. Riley said first that (Am. Ent., i, 188) "they have the full complement of 16 legs, but the two hindermost pair of abdominal pro-legs are much longer than the two foremost pairs;" on p, 298 of volume iii, he says: "The young worms have the first pair of pro-legs reduced in size." Dr. Lintner definitely states (Fifth Report, 202) that in the first stage "they had but three pairs of pro legs." At the first moult they acquired an additional pair, making four pairs of pro-legs; and after the second moult they had the normal number of five pairs of pro-legs. This is an interesting point and could be easily settled by referring to authentic specimens.

June 27th. As all of our observations were made under the unnatural conditions existing in greenhouses, they will not aid in determining the normal life-periods.

Thus, breeding experiments indicate that a brood of moths emerge in June, but most of the recorded captures at lights, etc., are later than July 7th and extend into November; Mr. Gillette found them most abundant in Iowa in October. It seems probable that the moths taken in September and October are members of a second brood, and the relatively rapid and early development of the insect in the spring would also indicate this. Yet there are no records of the finding of the early stages of the insect later than July in this country. Dr. Riley believed there were at least two and possibly three broods in the latitude of St. Louis.

How is the winter spent? The occurrence of the egg so early in the spring, and the fact that Mr. Gillette found that females taken as late as November 6th contained no fully developed eggs would indicate that the insect winters as a pupa or a moth, the eggs being laid in the spring. Yet the winter is sometimes passed as a cutworm, for. Prof. Forbes found a mature specimen in January in Illinois. Mr. French captured a fresh specimen of the moth as early as April 6th, indicating that the pupa hibernated.

On the whole, our knowledge of the life of this insect after July 1st is very indefinite

III. HOW TO COMBAT CUTWORMS.

Their unfortunate habit of cutting off much more food than they eat or need, their frequent occurrence in great numbers, and their nocturnal feeding habit render cutworms especially destructive insects and make them especially difficult to combat. They are destructive only during the cutworm stage, and usually noticeably so only after they have attained about two thirds of their growth. Furthermore, our most common species are destructive for only about a month, often less in corn fields, during the year; they are usually the most injurious in May and June. This short period of destructiveness is a very important consideration in connection with the problem of combating these pests, for whatever is done must be done quickly and its success or failure often rests within a very narrow margin. There is no doubt that many of the so-called "successful remedies" for cutworms were a "success" because they were applied at about the time the worms were maturing and disappearing into the ground for pupation; the "remedy" was applied and the cutworm disappeared, hence it was a success, and the fact that they may have disappeared in obedience to nature's laws is not taken into account.

These facts, and doubtless a difference in surroundings also, must account for much of the conflicting testimony regarding the efficacy of a majority of the scores of "remedies" with which our agricultural literature abounds. It is beyond the scope of this bulletin to enter into the history of all of these "remedies" that have been proposed. Only those methods will be discussed which seem practicable, whose efficiency has been thoroughly tested, and which are adapted to the special conditions under which the pests may have to be combated. The efficiency of any method will depend largely upon the time when it is applied and the person who applies it. Most of the methods thus far suggested are to be employed against cutworms when in their most destructive stage; most of the other recommendations for combating them at any other time or in other stage are principally guess-work. We do not yet know enough about the habits and life periods of the different stages of the insects to enable us to make such recommendations with definiteness and much hopefulness.

Before beginning the discussion of the methods adapted to special crops or conditions, we may properly discuss one method that is in no way connected with these. It is directed against the adult insect—the moth.

Trapping the moths.—Lights and sweets have great attractions for the owlet-moths at night, and some have suggested that they be made to serve as traps. Many different kinds of trap-lanterns have been patented (see Comstock's Report on Cotton Insects, pp. 262–275). There are two records of some of the results obtained by a continuous use of traps during the whole period of flight of most insects.

In 1891, Dr. Fernald kept eight of Barnard's Moth Traps* in operation day and night from April 21st to September 15th. The captures were examined each day, and in all over 17,000 Noctuid moths were taken; but the "number of parasitic flies (beneficial insects) captured during the same time was much larger than the entire number of injurious insects taken during the same period;" perhaps if the traps had been closed during the day, not so many of the parasitic insects would have been killed.

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* "These traps are glass jars, with a tin arrangement on top with holes around the side, near the top, through which the insects find their way to the inside of the jar which is partly filled with an odorous liquid strongly attractive to insects.

In 1889, six trap-lanterns* were set at considerable distances apart on the University farm for the purpose of determining their value as an insecticide. They were kept lighted every night from May 1st till October 15th, and all insects taken were removed every morning. A majority of the specimens taken were Noctuid moths, one species being especially numerous as shown by the table on page 664. In 1892, one similar trap lantern was run from May 20th till no more insects were attracted, with similar results. A striking fact shown by the table is the great preponderance of the males over the females; in 1889, less than 7 per cent. were females, and in 1892, about 30 per cent. This fact has also been noticed in every other species of the trap-lantern insects that have been studied. Many benificial insects were also taken in our trap-lanterns.

The maintaining of these trap lanterns and baited traps involves more labor and expense than their doubtful results can repay, and besides they may be a positive detriment by destroying certain beneficial insects.

CUTWORMS THAT CLIMB.

Clean cultivation.—If the peach orchards and vineyards that suffer from climbing cutworms could be kept entirely free from all other vegetation, weeds included, for two or three months after July 15th, we believe there would be much fewer cutworms there the following spring. It is during this period, undoubtedly, that most of the eggs are laid and the young cutworms are getting one half or two-thirds of their growth on the weeds and grasses, preparatory to going into winter quarters. If none of this food is allowed to grow about the trees or vines at this time, the moths will be apt to go elsewhere to oviposit, and what cutworms did hatch would soon starve.

It may be possible to afterward start a crop of wheat or rye to be plowed under as green manure in the spring, but this can not be

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* They consisted simply of a common lantern set in a pan of water whose surface had a thin film of kerosene upon it to facilitate the destruction of the insects caught.

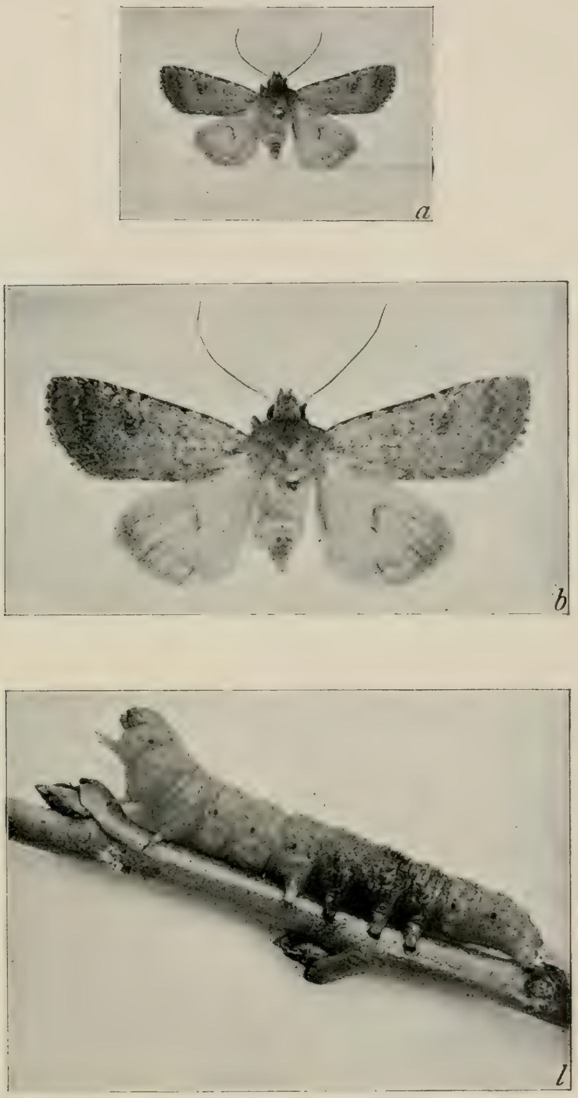


Plate I.— The white cutworm (*Carneades scandens* Riley). *a*, the moth, natural size; *b*, the moth, twice natural size; *l*, the cutworm, twice natural size.

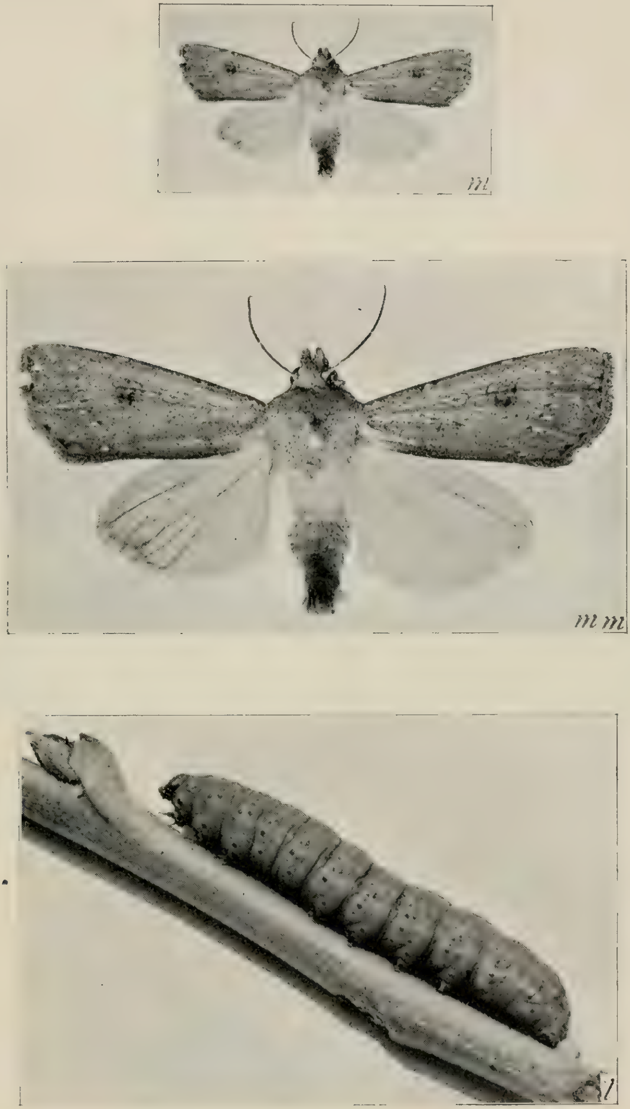


PLATE II.—The spotted-legged cutworm (Porosagrotis vetusta Walker). *m*, the moth natural size; *mm*, the moth, twice natural size; *l*, the cutworm, twice natural size.

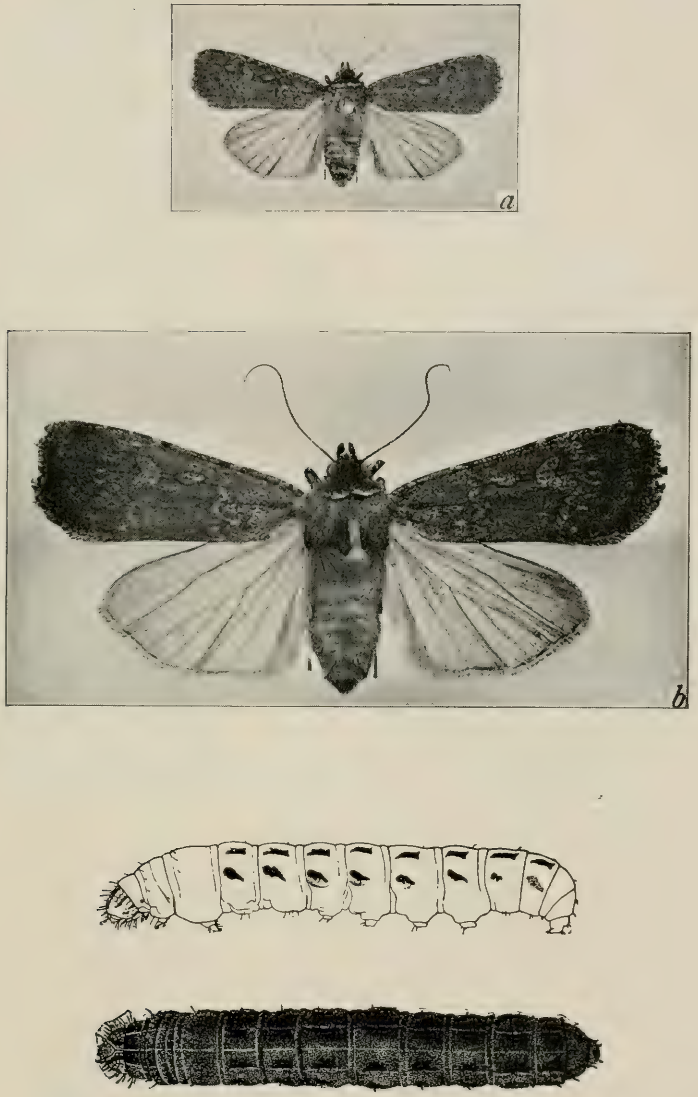


Plate III — The well-marked cutworm (*Noctua clandestina* Harris) The cutworm, side and back view, twice natural size (after Forbes). *a*, the moth, natural size; *b*, the moth, twice natural size.

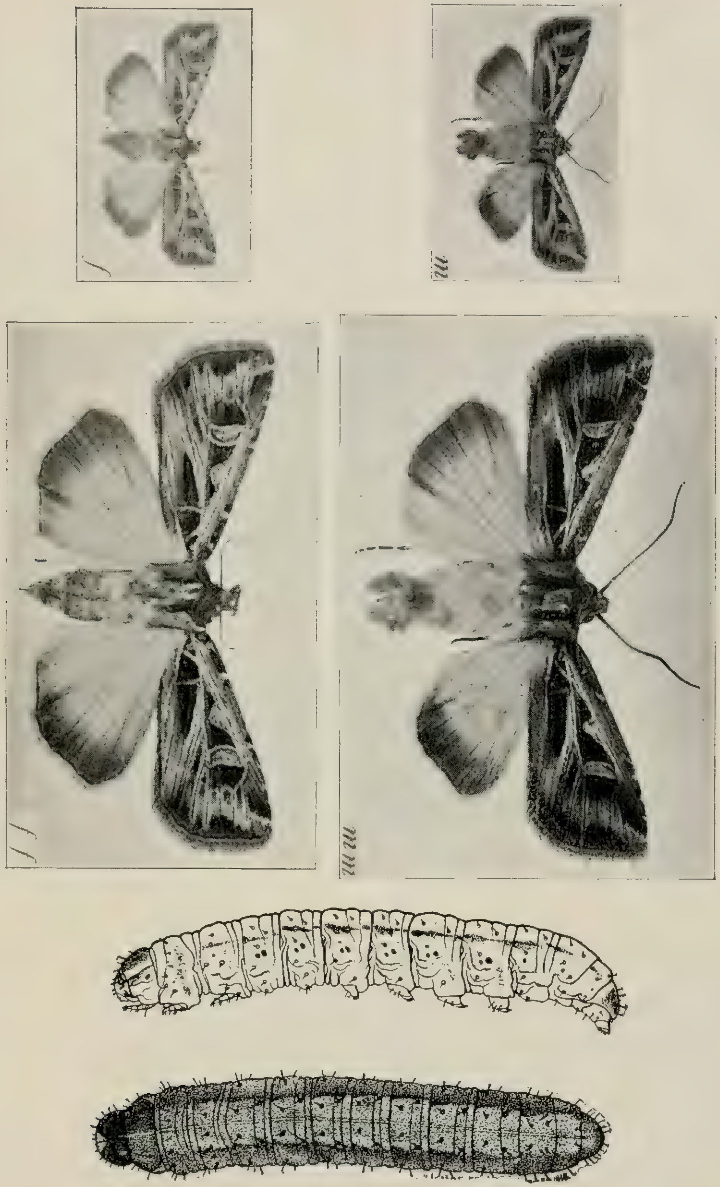


PLATE IV.—The dingy cutworm (Feltia subgothica Haworth). *m*, and *f*. male and female moths, natural size; *mm* and *ff*, male and female moths, twice natural size. Side and back views of the cutworm, twice natural size (after Forbes).

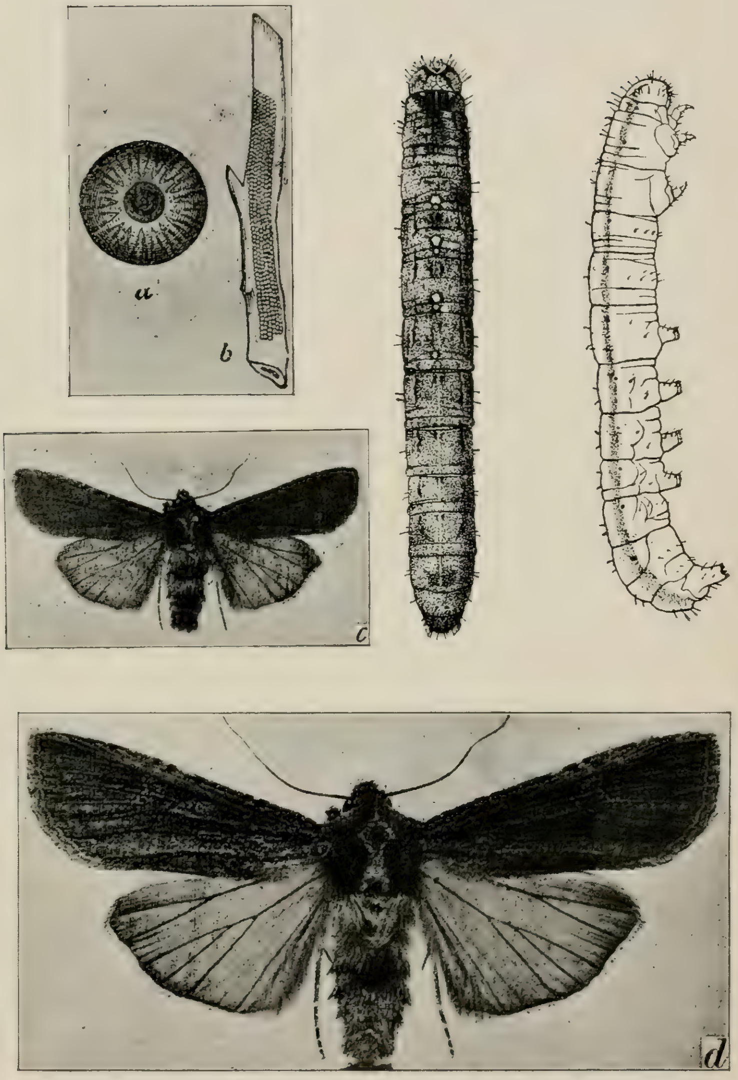


Plate V.—The variegated cutworm (Peridroma saucia Hübner). *a*, an egg, greatly enlarged; *b*, cluster of eggs, natural size; *c*, the moth, natural size; *d*, the moth twice natural size. Side and back views of the cutworm, twice natural size (after Forbes)

advised here until we know more about the egg-laying habits and fall life of the insects.

The effectiveness of this method of clean cultivation will depend entirely upon the thoroughness with which all weeds and grasses are kept out. Even then it may prove of no avail if the field is surrounded by old grass or clover fields from which a stock of cutworms might migrate in the spring.

Attractive-crops.—Doubtless few cutworms will assume the climbing habit except when forced to do so by the absence of low-growing plants. Wherever trees are set in grass, or other garden or field crops are grown between them, it is noticeable that the cutworms usually trouble the trees but little. One correspondent found that when the potatoes he planted between his peach trees got large enough, the cutworms left the trees and began cutting off the potato stalks. Another correspondent found that when he sowed rye in his vineyard, his vines were not injured. Thus attractive crops are sometimes a success as far as keeping the worms off the trees is concerned.

Possibly the following suggestions regarding attractive-crops may be of value when setting a peach orchard or vineyard in the sandy soils of western New York. Whether the stock is set in the fall or spring, keep the field free of all vegetation after the preceding 15th of July until the latest date at which rye or wheat can be sown and obtain a good stand. Sow the field and either plow the crop under in the spring for green manure, or let it continue to grow as a grain crop if desired. If it is plowed under, it should be done as early as possible before the buds on the trees or vines start, and some quick growing crop be gotten in at once to trap the worms; or do not plow it under until after the leaves appear, as the worms then would not injure the trees so much. Whatever crop follows the rye or wheat should be one that can be gotten out of the way before August 1st, and the ground be kept entirely free from any vegetation until time to put in another rye or wheat crop late in the fall. Such a rotation is practicable and could be profitably carried out for the first two or three years without interfering much with the growth of the orchard or vineyard. After that the trees or vines need all the fertility in the soil, and they are then sometimes large enough to withstand an ordinary attack of cutworms; if not, then some of the following remedial measures must be resorted to:

How to prevent them from getting to the buds.— This can be accomplished in several different ways.

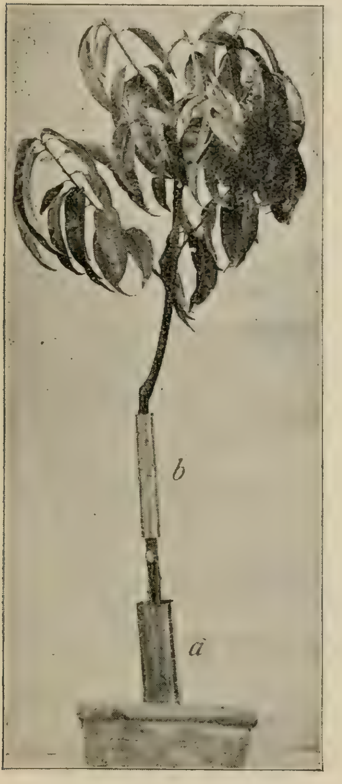
Some have used coal-tar for this purpose, painting a band of it around the trunks of the trees; it has killed some young trees and is not effectual unless renewed every few days.

Another sticky substance, known as Caterpillar Lime ("Raupenleim," a German product), is now coming into use in this country and was tested on Michigan peach trees last spring. Mr. G. C. Davis, the experimenter, reported that "it worked nicely except on very cool nights, when it was apt to become a little too stiff and then the cutworms would scramble over." It is a black paste with a strong tar-like odor; a good thick band of it on the trunk of a tree will remain sticky for weeks, and rains do not affect it. It can be obtained of Messrs. Wm. Menzel & Son, 64 Broad street, New York City, for $3.75 per keg of 25 pounds; a pound will cover the whole trunk of a tree four or five inches in diameter. A much cheaper, and nearly as effective, substance has recently been compounded by Prof. F. L. Nason, New Brunswick, N. J. It is known as "Dendrolene," and can be obtained of the maker for 6 cents per pound in lots of 25 to 50 pounds. Either substance gives promise of being a very cheap and effective means of preventing cutworms from getting at the buds of trees or grapevines.

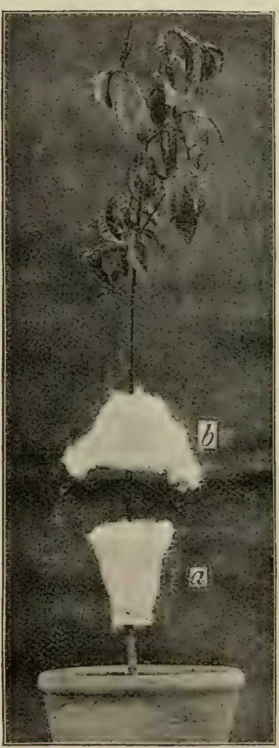
A mechanical device which is oftenest recommended is a tube of tin fitted around the tree in some such way as is shown in Fig. 146. In earlier accounts this is termed "an effectual estopper to further proceedings." We have not tried it nor seen it in use, but Mr. Davis experimented with it in Michigan last spring, and he reports "the tin collar is but little better than nothing. The cutworm, when it comes to the collar, will travel around until it comes to the lap, or where the two ends meet, and then it climbs up almost as readily as on the bark. It is more difficult to fit to the tree than a band, and is more expensive." This method should thus receive no further attention, as its efficiency is very doubtful, and here are, also, other simpler, cheaper and more effective devices.

A stiff, smooth paper, several inches wide, wound around a tree, tied tightly at the top and pulled out slightly at the bottom to give it a funnel shape, has been found quite successful. We devised a tarred-paper protector on the same plan as Mr. Goff's pads for the cabbage maggot. These could be quite readily applied to the trees, and formed a good funnel; but correspondents reported that the cutworms crawled over them without any difficulty. Any similar funnel-shaped arrangement will be more expensive, more difficult to apply, and not more effectual than the following simple device:

In 1885, several Michigan peach-growers used a collar of cotton batting, tied around their trees and vines, with success against the cutworms. When we investigated the pests at Forest Lawn in 1894, we found several peach orchards in which every tree had a collar of this batting around it. One man had thus protected 800 young trees, using only eight rolls of batting; thus, the principal part of the expense was in applying the bands. The very ingenious manner in which it had been applied is illustrated in Fig. 147.



146.—The manner of applying the tin-cylinder protectors.



147.—The best way to apply the cotton-batting protectors.

Thin sheets of the batting were unrolled and cut or torn into strips about four or five inches wide and long enough to wrap around the tree and overlap an inch or more. After being wrapped about the tree, it is tied *at the bottom*, as illustrated at *a* on the tree in Fig. 147. After tying, the operator takes hold of the top of the band and carefully rolls it down over the bottom edge, thus forming a cotton-batting funnel, as represented at *b* in Fig. 147. Mr. Glasser, who placed the cotton bands on in this ingenious way, had found that ordinary white twine was the best cord to use, for larger, stronger cord (like binder's twine) would not stretch enough to allow for the growth of young trees; some of his trees were so nearly cut through with this large twine that they were broken off by the winds during the winter. This method of applying the batting not only makes it a more effective barrier against the cutworms, but it is also not easily matted down by rains. We found that a few hours of sunshine would make it as fluffy and effective as ever. When properly put on, a cutworm very rarely got over them. In Mr. Davis' experiments in Michigan last spring he found a cotton batting band to be the best and cheapest device as long as it remained dry, but its liability to mat down led him to recommend that wool be used instead.

In 1894, we took some wool to Forest Lawn to be used in this way, but our observations convinced us that Mr. Glasser's ingenuous method of applying the cotton rendered it unnecessary to use the more expensive wool, except possibly in seasons of continuous rainfall. The wool bands will prove equally as effective, and so far as preventing the cutworms from getting to the buds of either grapevines or peach trees is concerned, nothing more simple or effective need be asked for. They should be applied early in the spring, as soon as the buds begin to swell or the cutworms appear.

As preventive methods against climbing cutworms, we would therefore advise the use of the cotton or wool bands, or possibly the caterpillar lime, and also, as a part of the regular farm practice, the growth of such attractive crops among the trees or vines as will allow for a period of clean cultivation in late summer and early fall.

How to kill the climbing cutworms.—One should not be satisfied with simply preserving the buds from the greedy creatures. They should not be allowed to remain a constant menace to the trees and other near-by crops, but a war of extermination should be inaugurated at once. This fact was emphasized in one orchard at Forest Lawn in 1894. The owner had effectively protected the buds with the cotton bands, but we found him taking them off, although there were then many cutworms in the soil at the base of the trees. When questioned, he showed us several trees where the bark had been eaten off in large patches on the trunks just below the bands, sometimes nearly girdling small trees. The bands had even then better have been left on the trees, but the instance served as an illustration of the necessity of killing the pests to prevent their further depredations and their future multiplication for another crop of cutworms to harass the fruit-grower the next season. They can be easily killed in several ways with a very little extra labor.

While at work at night, they can be readily jarred onto sheets (perhaps a curculio-catcher might be used in some cases) and then killed or fed to poultry. The best time would be about nine or ten o'clock, and it must be continued every night for about two weeks, beginning as soon as the buds begin to swell in the spring. In most cases this will prove a more laborious process than some others to be suggested.

Hand-picking always carries with it the suggestion of too much work, and yet no one can doubt its effectiveness, and it is a very practicable and profitable method in many cases. It was the method employed by the Indians in this country centuries ago to protect their corn from cutworms.* It can be profitably applied in the case of climbing cutworms, either in connection with the cotton protectors or separately.

At Forest Lawn, one fruit-grower had his boy go out every night with a lantern and pick off and kill all the worms found on the

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*In the account of his voyage to New England, printed in London in 1672, Josselyn gives the following quaint description of this method as he saw it practiced: "There is also a dark, dunnish Worm or Bug of the bigness of an Oaten-straw, and an inch long, that in the Spring lye at the root of Corn and Garden plants all day, and in the night creep out and devour them; these in some years destroy abundance of *Indian* Corn and Garden plants, and they have but one way to be rid of them, which the *English* have learned of the Indians; and because it is somewhat strange, I shall tell you how it is, they go out into a field or garden with a Birchen-dish, and spudding the earth about the roots, for they lye not deep, they gather their dish full which may contain a quart or three pints, then they carrie the dish to the Sea-side when it is ebbing water and set it a swimming, the water carrieth the dish into the Sea, and within a day or two you go into your field you may look your eyes out sooner than find any of them."

trunks of his trees below the cotton protectors. A Michigan grower does not stop to pick them off, but with an old leather mitten on his right hand, he crushes those that have gathered on the trunks below the bands. He also places some pieces of rough boards around the base of his trees, and many cutworms gather under them to hide during the day. He collects these every morning and feeds them to his poultry. These are all valuable suggestions.

One extensive peach grower at Forest Lawn has practically exterminated the pests in his young orchard by a systematic digging of them out during the day. He found that a majority of them buried themselves to a depth of not over an inch in the sand around the trees for a distance of from one to two feet from their base. Soon after the first indications of their work in the spring two men and himself went from tree to tree and dug out the worms; the three men could thus go over 500 of the young trees in half a day. By keeping this up for several days the depredations of the pests were ended for the year, and he finds them much less troublesome the next year. In this case hand-picking was profitable, practicable and effective and no protective method had to be resorted to. It is not an exceptional case, but can be duplicated in many infested orchards and vineyards; in greenhouses, also, the pests can soon be exterminated by hand-picking them at night by lantern light, or by digging them out of the soil around the base of the plants during the day. If practiced in connection with clean cultivation, recommended above, it will prove in many cases the cheapest and most lasting method of fighting climbing cutworms.

Climbing cutworms can also be poisoned. The spraying of the buds in the spring with Paris green has been tried several times, but with little success, for the cutworms are not killed quickly enough to save the trees.

In 1875 poisoned baits were used by Dr. Riley in Missouri, and since then they have come into quite general use and have been strongly recommended by several writers on cutworms. Until recently these baits consisted of large leaves or bunches of weeds, grass or clover freshly cut and dipped in a strong Paris green mixture (1 pound to 50 or 100 gallons of water). These are placed in the infested fields at nightfall, and the cutworms are often attracted to them in preference to their usual food. The next morning many of the cutworms will often be found dead or dying beneath the baits, and they will have been their own sextons and have attended to their own burial in many cases. Such poisoned baits seem not to have been used against climbing cutworms, but a single trial on a small scale here at the insectary leads us to believe that they would prove quite effective in connection with cotton bands. Place two or three of the poisoned bunches close to the base of the tree or vine at nightfall.

One correspondent wrote us that when he uses the cotton bands he often finds the cutworms feeding on the little twigs that have been cut from the trees. Why not poison these twigs? A Michigan fruit-grower dips small freshly-cut branches into a strong arsenical solution and sticks them into the ground around the trees close to the trunk. He says the cutworms take to the limbs in preference to the taller trees and are killed by the poison.

In 1894 we found several persons near Forest Lawn who had used with considerable success a poison bait made by mixing enough Paris green with rye flour to give it a distinct greenish tinge. This was scattered around the base of the infested plants; it was greedily eaten by the worms and with deadly effect. We tried it on a small scale and found it quite effective. Of course, all poultry and other domestic animals must be kept away from the places where this bait and the one to be discussed next are being used.

While experimenting on grasshoppers with the poisoned bran mash, which has been used with some success against these pests in the West, it occurred to us to try it on the climbing cutworms.* A few preliminary experiments in 1894 convinced us that it would prove a very effective bate for the cutworms, as they ate it greedily when placed about peach trees, and it killed very quickly. We applied it at nightfall, and the next morning found several dead and dying cutworms, with the contents of their alimentary canal so green that it showed plainly through their skin; a chemical examination of the green portion showed very strong indications of

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*It is made by *thoroughly* mixing sufficient Paris green or London purple with dry wheat bran to give it a distinct greenish or purplish tinge (a pound to 25 pounds of bran, or two or three pounds of the cheaper white arsenic may be used), then add enough water to form a mash sufficiently soft to be dipped out with spoon without dripping. Sugar, molasses or glycerine may be added to the water to make the mash more sticky or to prevent its drying out so quickly, but Mr. Davis found that the sweeting did not add to the attractiveness of the mixture for the cutworms.

arsenic, proving that the poison in the mash had done its deadly work.

One of our correspondents tried this mash, and he reported that on the second day after it was applied he found the ground beneath his peach trees "covered with dead worms. As long as we can get the cotton bands and this poisoned bran mash, I do not think we need worry about the cutworms." Last spring, Mr. Davis tested the mash in Michigan. He reports: "It was dropped in little bunches around the base of each tree. The cutworms ate it readily both as they passed it in starting up the tree and as they came back hungry from their vain effort to get beyond the band. The next morning more than half of the cutworms would be found hanging to the bark, limp and dead, or in the same condition on the ground. In some cases 90 per cent. were killed."

In 1894, a man in California completely destroyed the worms in a vineyard of thirty acres before any damage was done: he used three pounds of Paris green to a sack of rye bran. A handful or so of the mixture was thrown about the trunk of each vine. The evidence thus far indicates that this poisoned bran mash is the most effective and practicable method of killing climbing cutworms with poisons; where the cutworms are very numerous the cotton protectors will, doubtless, have to be used in connection with it. It will, doubtless, prove equally as effective when used in greenhouses to combat these pests.

There are, thus, several methods by which the destructive work of climbing cutworms can be prevented; and, also, several other methods that may be used in connection with or separate from these by which they can be killed. At least, some of these methods can be made efficient, practicable and profitable under any of the varying conditions which may exist in infested orchards or vineyards. It is true that each one involves some labor on the part of the fruit-grower, but he must expect this if he hopes to compete with his more energetic neighbor.

IN GARDENS.

Preventive measures.—Gardens planted on newly-plowed meadows, pastures or grain stubble are more liable to attacks from cutworms, for such fields are the natural breeding places of the pests. However, they often appear in garden crops that have been grown in the same location for many years; a striking instance of this was the sudden appearance of a cutworm in excessive numbers in the onion fields of Orange county, N. Y., in 1885. Usually, the sod is plowed under only a short time before the garden is planted, and the hungry worms eagerly await the appearance of the crops; if all stubble and rubbish could be burned off just before ploughing it might destroy some of them, and possibly the eggs of some species. If such lands were ploughed the preceding July or August, and clean cultivation practiced, as described for climbing cutworms, we believe the garden crops planted the next spring would be much less liable to suffer from cutworms.

Cabbages, tomatoes and similar plants that are set out in gardens, and which are very liable to be cut off by cutworms, may often be protected by simply wrapping a piece of smooth, stiff paper around the stem when the plant is set; we have seen the tinfoil from tobacco pails or packages used for this purpose with much success. Cylinders of tin (old tomato cans with the ends removed will often answer) have been placed around such plants, and in many cases they served as perfect protectors.

Cutworms often appear first in destructive numbers in certain portions of the garden. Their spread to other portions may often be prevented by ploughing a deep furrow around the infested portion, turning it toward this portion, and leaving as smooth and perpendicular a wall as possible on the side of the furrow bordering the uninfested region; the worms can not readily scale this smooth wall. The furrow can be made much more effective by digging deep post-holes in it a rod or two apart, into which the worms will soon crawl in their wanderings; bushels of army worms have been trapped in these holes. This method should be resorted to whenever the worms appear in excessive numbers and ordinary measures prove fruitless. By thus confining them to a limited area, some of the destructive measures advised can be used with more deadly effect than if the worms are allowed to spread over a large area.

It is doubtful if any bad-smelling substances placed on the soil around the plants will keep away cutworms. They will, also, burrow in dry salt, lime and ashes, as readily as in dirt.

Destructive measures.—Usually none of the preventive measures just discussed will afford complete protection from cutworms, and destructive measures have to be resorted to.

We do not believe that commercial fertilizers, gas-lime, lime, salt, or any similar dressings applied at any time to the soil *in* *practicable quantities* will have any destructive effects on cutworms. In some cases they may stimulate the plants to such an extent as to enable them to quickly get beyond or outgrow cutworm injuries.

Applications of any kind to the plant are not always successful; if the worms confine their work to the leaves, they may be reached by thorough work with a Paris green spray. During the outbreak in the onion fields mentioned, it was found that they were very susceptible to kerosene and many were killed by spraying the plants at night with it. As the undiluted kerosene injures many plants, the kerosene emulsion has been advised instead, and it may prove a valuable destructive agent where the worms appear in excessive numbers. It should be applied at night when the worms are at work, and the strength at which it can be used will have to be determined for each crop, as plants differ much in their susceptibility to injury from it.

Probably the method most often practiced in gardens, and which can not fail to be effective when faithfully carried out, is hand-picking with lanterns at night or digging them out from around the base of the infested plants during the day. Bushels of cutworms have been gathered in this way and with profit. When from some cause success does not attend the use of the poisoned baits, discussed next, hand-picking is the only other method yet recommended which can be relied upon to check cutworm depredations.

By far the best methods yet devised for killing cutworms in any situation are the poisoned baits; hand picking is usually unnecessary where they are thoroughly used. What has been said in regard to their use against climbing cutworms has equal force here. Poisoned bunches of clover or weeds have been thoroughly tested, even by the wagon-load over large areas, and nearly all (Mr. Goff's experiment at the Wisconsin Station is the most notable exception reported) have reported them very effective; lamb's-quarters, pepper-grass, and mullein are among the weeds especially attractive to cutworms. On small areas the making of the baits is done by hand, but they have been prepared on a large scale by spraying the plants in the field, cutting them with a scythe or machine, and pitching them from wagons in small bunches wherever desired. Distributed a few feet apart between rows of garden plants at nightfall, they have atttacted and killed enough cutworms to often save a large proportion of the crop; if the bunches can be covered with a shingle, they will keep fresher much longer. The fresher the baits, and the more thoroughly the baiting is done, the more cutworms one can destroy.

However, it may sometimes happen that a sufficient quantity of such green succulent plants can not be obtained early enough in the season in some localities. In this case, and we are not sure but in all cases, the poisoned bran mash can be used to the best advantage. It is easily made and applied at any time, is not expensive, and thus far the results show that it is a very attractive and effective bait. A tablespoonful can be quickly dropped around the base of each cabbage or tomato plant, small amounts easily scattered along the rows of onions, turnips, etc., or a little dropped on a hill of corn, cucumbers, etc. It was used on sweet potato hills in New Jersey last year and "served as a complete protection, the cutworms preferring the bran;" it is well to apply it on the evening of the day the plants are set out.

The best time to apply these poisoned baits is two or three days before any plants have come up or been set out in the garden. If the ground has been properly prepared, the worms will have had but little to eat for several days and they will thus seize the first opportunity to appease their hunger upon the baits, and wholesale destruction will result. The baits should always be applied at this time wherever cutworms are expected. But it is not too late usually to save most of a crop after the pests have made their presence known by cutting off some of the plants. Act promptly and use the baits freely.

IN GRASS-LANDS AND FIELD CROPS.

Unplowed fields are the natural feeding grounds of cutworms, and where the sod is not disturbed for several years, they are liable to accumulate in such numbers as to sometimes greatly reduce a crop of clover or timothy and often ruin any crop like corn or wheat that may follow. The fact that timothy meadows usually remain unplowed for several years, thus allowing the cutworms to accumulate, doubtless explains why corn and other crops planted on such land are so often badly injured by these pests. There is no practical method of checking cutworms in pastures, meadows, and clover or grain fields without involving the destruction of the plants also. On grain and hay farms then, the best method that can be advised to prevent cutworm depredations is to practice a short rotation of crops. Never let any field lie in sod for more than two years in succession. Those who practice this are rarely troubled with cutworms, even in cornfields. What crops shall constitute the rotation must be determined by the individual for his locality and soils.

In corn fields. — From the earliest times, cutworms have done more damage to corn than to any other crop. Almost every year thousands of acres have to be replanted in this country. This is largely to be explained by the fact that corn is the crop most often planted on newly-plowed lands that have usually lain in sod for several years and are thus often full of the pests. If the preparation of corn ground were begun the preceding summer, as described at the beginning of the discussion of the measures adapted to garden crops, we believe much less corn would have to be replanted on account of cutworms. It is doubtful if either early or late fall, or early or late spring plowing, each of which has its advocates, will in itself have much effect on the crop of cutworms that may appear in the spring; the soil must be more than simply plowed.

Many recommendations have been made to prevent the attacks of cutworms on corn, and two of these have especially commended themselves to some eminent writers on these insects. These are first, the application of salt, either by soaking the seed in strong brine or by sprinkling a tablespoonful on the hill immediately after planting; and second, the soaking of the seed in a solution of copperas. Each recommendation is backed by seemingly strong testimony from farmers They theorize that in each case some of the salt or copperas finds it way into the tissues of the young plant and renders it distasteful to the worms. Possibly an exceedingly small amount of the minerals might thus get into the plant, but it is very improbable that enough would to render it unpalatable to hungry cutworms which can eat onion-tops, tobacco-stalks and all kinds of weeds with relish.

We now know that the mere soaking of seeds in water brings in a very important factor which may influence the whole after-life of the plant. All know that soaked seeds sprout quicker, and it has been shown by careful experiments (with hot water) that from such seeds a much more vigorous and productive plant will grow. In the evidence submitted in support of the methods of soaking the corn in brine or a copperas solution, it is clear from the context that the seed in the comparison or check fields was not soaked in water, as it should have been to have eliminated the very important factor just described. We believe that if the soaking of the corn in the solutions mentioned had any preventive effect on the cutworms, it resulted from the fact that the plants from such seed got a better and more vigorous start;* the cutworms would naturally prefer the smaller and more succulent stalks. Ordinary water would have doubtless answered the same purpose. We should have more careful, scientific experiments in this line before we advise farmers to soak their corn in any solution with the hope that they may thereby render the stalks distateful to cutworms. Soaking in water will doubtless do just as much good, and it is not impossible that in some cases this may materially help in our warfare against these insects in corn fields.

Where a short rotation of crops is practiced, cutworms rarely do serious damage in the corn field. The methods we can suggest by which they can be killed in such locations are digging them out by hand, and by the use of the poisoned baits of clover, weeds, are the bran mash. A spoonful of the poisoned mash on each hill would doubtless soon furnish a deadly meal for most of the worms in or near the hill. Hand-picking has been practiced in corn fields of many acres with success and profit. It is not such a tremendous job as it seems if one only goes at it systematically.

Where the presence of cutworms is suspected, it is wise to put in plenty of seed; follow the old distich:

"One for the black-bird and one for the crow,
Two for the cutworm and three to grow."

MARK VERNON SLINGERLAND.

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* Dr. Harris held a similar opinion as early as 1841. He says: "Such stimulating applications may be of some benefit, by promoting a more rapid and vigorous growth of the grain, by which means the sprouts will the sooner become so strong and rank as to resist or escape the attacks of the young cutworms."

NOTICE TO CORRESPONDENTS.

Inquiries about insects should always be accompanied by specimens of the insects, and of their work, also, if possible. Without specimens, our answers must often be indefinite and unsatisfactory. Send as full an account as possible of the habits of the insect about which information is wanted. Living insects can be safely sent by mail if enclosed in small, tight tin or wooden boxes; no air holes are necessary. Do not use pasteboard boxes nor enclose the specimens in an envelope with the letter of inquiry; such specimens, if they reach us at all, are usually crushed beyond recognition. Specimens can be sent in tightly corked glass bottles inserted in holes bored in blocks of wood or placed in wooden mailing cases made for this purpose. The space not occupied by the insects should be filled with some of their food. The postage on such packages is one cent per ounce. The name of the sender should be placed on the package.

Address all communications about insects, with the accompanying specimens, to

M. V. SLINGERLAND,
Ithaca, N. Y.

BULLETIN 105—December, 1895.

Cornell University—Agricultural Experiment Station.

AGRICULTURAL DIVISION.

LIBRA
NEW YO
BOTANICA
GARDEN

Tests of Cream Separators.

By Henry H. Wing.

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The regular bulletins of the Station are sent free to all who request them.

BULLETINS OF 1895.

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85. Whey Butter.
86. Spraying of Orchards.
87. The Dwarf Lima Beans.
88. Early Lamb Raising.
89. Feeding Pigs.
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105. Tests of Cream Separators.

Tests of Cream Separators.

One of the most important points in the economy of butter manufacture is the efficiency with which the cream is separated from the milk. The introduction of the centrifugal separator marked a great advance in this direction and the rapid development and improvement of these machines, by the business competition of the various manufacturers, renders the question of the most efficient kind of separator an important one for the creamery operator or private dairyman.

During the session of our Short Dairy Course for 1894, a series of tests of various styles and sizes of separators was made and published in Bulletin 66 of this Station. Previous to this, and at the same time, tests of separators were made at several other Stations, notably in Vermont and Pennsylvania and to these reference will be made later on.

The edition of Bulletin 66 having been exhausted and inquiries as to the matters contained therein still continuing, another series of tests was made during the Short Dairy course of 1895. The machines used were the same, with one or two exceptions, and were as follows:

The Butter Accumulator manufactured by the Swedish Cream and Butter Separator Co., Bainbridge, N. Y. This machine was run in our tests only as a separator.

The DeLaval, Acme Alpha size, manufactured by the DeLaval Separator Co., 74 Cortlandt St., New York, N. Y.

The DeLaval, Baby No. 3 size, manufactured by the DeLaval Separator Co., 74 Cortlandt St., New York, N. Y.

Reid's Improved Danish, manufactured by A. H. Reid, 30th and Market Streets, Philadelphia, Pa.

The United States, No. 3 size, manufactured by the United States Butter Extractor Co., Newark, N. J. The Vermont Farm Machine Co., Bellows Falls, Vt., sole agents.

The Victoria, 75 gallon size, manufactured by Watson, Laidlaw & Co., Glasgow, Scotland. The Dairymen's Supply Co., 1937 Market St., Philadelphia, Pa., agents in the United States.

All of these with the exception of the Reid's Improved Danish and the DeLaval Alpha Acme, were the same machines that were used in 1894. The Butter Accumulator, the DeLaval Acme Alpha and the Reid's Improved Danish were loaned for the purposes of the school by the respective manufacturers.

These machines were operated by the students in the Dairy course under the direct supervision of Mr. Jared VanWagenen, Jr., instructor in butter making, each student working in turn upon each separator. None of the tests recorded were made until after the class had been at work for nearly a month and the students had had a considerable amount of practice in handling the various machines. The milk used was, in all cases, the mixed milk brought to the dairy building by farmers nearby. The milk of the morning and the previous evening was delivered at the building at about 10 A. M. and worked up the same day. It was ordinarily received in good condition but a considerable portion was the milk of "stripper" cows and may be considered difficult milk to separate.

As the runs were short, it was not attempted to make the test of capacity by weighing the milk and taking the time of the whole run. After the machine was started and the milk had been running at full head for some little time, a capacity test was made by catching and weighing the skim milk and cream for a certain short definite time.

Owing to the pressure of work upon the Station chemist, it was not found possible to determine the fat in the skim milk by the gravimetric method as heretofore, and the determinations were therefore made in all cases in skim milk Babcock bottles and by the same person, Mr. J. M. Trueman, an advanced student in the College of Agriculture. The samples in all cases, were taken from the mixed skim milk of the entire run and not caught directly from the skim milk outlet of the machine at any period of the run. The skim milk was caught in 40-quart cans and a portion taken from each can with the Scovell Aliquot Sampler. These portions mixed together formed the sample for analysis. The details of the working of the various machines are shown in Tables I to VI below.

In general, the mechanical operations of the machines were very satisfactory. They were mounted on solid stone piers and run smoothly and evenly. Very little difficulty was found in uniformly maintaining the required speed, and only a few points in regard to the general work of the various separators need special mention. Reid's Improved Danish was the most difficult to keep up to the required speed. Because of the large diameter and heavy weight of the bowl, it was difficult to keep the belt sufficiently tight to prevent more or less loss of speed through slipping. Otherwise than this, this machine presents some peculiar features which are of advantage, notably the ease with which the thickness of the cream may be regulated at will while the bowl is in motion and the thickness and uniformity with which the cream is delivered.

In regard to the DeLaval machines it is proper to notice the comparatively large capacity in proportion to size of the bowl and the low speed at which the machines can be run and still secure practically perfect separation. The smoothness and uniformity of the cream is also a valuable feature of these machines.

The only machine that gave any trouble by delivering thick or lump cream was the Victoria. It was found that considerable care was necessary in order to prevent this.

TABLE I.—BUTTER ACCUMULATOR (USED AS A SEPARATOR).

RATED CAPACITY, 400 POUNDS PER HOUR.

DATE.	Pounds of milk used.	Temperature of milk.	Revolutions of bowl per minute.	Pounds separated per hour.	Per cent. of fat in skimmed milk.
Feb. 7	312	87	7,250	428	.05
14	....	....	....	394	.05
18	495	85	7,000	436	.10
26	172	86	7,500	....	.10
28	....	....	7,500	426	.20
Mch. 1	172	....	8,000	....	.01
4	204	85	7,250	467	.20
7	215	84	7,500	354	.10
8	150	86	7,500	400	.10
9	330	86	....	408	.10
Average	....	86	7,438	414	.10

TABLE II.—DeLAVAL, ACME ALPHA.

RATED CAPACITY, 1,300 POUNDS PER HOUR.

DATE.	Pounds of milk used.	Temperature of milk.	Revolutions of bowl per minute.	Pounds separated per hour.	Per cent. of fat in skimmed milk.
Feb. 25	2,318	86	6,600	1,114	.05
26	944	84	6,600	1,129	.05
28	....	....	6,500	1,106	.05
Mch. 1	748	80	6,000	1,101	.05
4	993	87	6,000	1,097	.05
6	1,002	86	....	1,061	.05
8	1,314	86	6,000	1,067	.01
11	1,235	80	6,150	1,058	.02
12	....	....	6,000	1,082	.01
13	663	90	6,000	1,044	.05
16	1,398	84	6,000	1,099	.05
18	....	....	....	1,097	.10
19	236	....	....	....	.05
Average	....	85	6,185	1,088	.05

TABLE III.—DeLAVAL, BABY No. 3.

RATED CAPACITY, 600 POUNDS PER HOUR.

DATE.	Pounds of milk used.	Temperature of milk.	Revolutions of bowl per minute.	Pounds separated per hour.	Per cent. of fat in skimmed milk.
Feb. 19	256	85	5,720	554	.05
21	384	86	5,775	551	.05
23	503	....	5,830	570	.01
25	245	89	5,500	....	.05
28	152	85	5,665	551	.01
Mch. 1	....	....	5,830	549	.05
4	422	90	5,775	545	.05
5	510	94	5,610	556	.05
11	624	88	5,720	580	.10
13	235	....	....	572	.05
18	368	85	5,775	558	.05
19	....	....	....	571	.05
20	262	84	5,720	568	.15
Average	....	87	5,720	560	.06

TABLE IV.—REID'S IMPROVED DANISH.

RATED CAPACITY, 2,000 POUNDS PER HOUR.

DATE.	Pounds of milk used.	Temperature of milk.	Revolutions of bowl per minute.	Pounds separated per hour.	Per cent. of fat in skimmed milk.
Feb. 11	2,591	80	4,500	1,619	.01
14	1,680	86	4,000	1,284	.01
21	1,720	85	4,000	1,997	.20
23	2,194	88	4,000	1,910	.10
25	1,379	81	4,300	2,083	.10
Mch. 4	3,618	82	4,400	2,054	.15
9	2,293	85	4,200	1,951	.10
11	2,850	80	4,100	2,002	.25
12	1,141	78	4,200	2,007	.05
14	1,719	85	5,000	1,987	.20
15	534	83	5,000	1,906	.01
18	1,935	85	5,200	2,021	.15
20	1,892	84	5,400	1,963	.15
Average	....	83	4,485	1,906	.11

TABLE V.—UNITED STATES, NO. 3.

RATED CAPACITY, 600 POUNDS PER HOUR.

DATE.	Pounds of milk used.	Temperature of milk.	Revolutions of bowl per minute.	Pounds separated per hour.	Per cent. of fat in skimmed milk.
Feb. 11	....	....	7,900	575	.05
12	559	80	7,900	534	.10
15	395	95	7,750	577	.05
16	330	90	7,600	568	.07
20	385	87	7,750	584	.05
25	310	89	7,000	....	.05
26	246	87	7,750	567	.05
Mch. 1	207	85	7,750	569	.05
1	172	90	8,000	594	.05
4	177	85	7,100	584	.05
7	318	88	....	575	.10
12	296	86	7,900	560	.01
12	173	85	7,200	572	.01
14	544	85	7,500	536	.05
14	....	....	....	557	.05
16	518	88	7,500	533	.05
18	....	....	7,400	565	.10
19	233	86	7,250	545	.05
20	194	86	....	527	.01
Average	....	87	7,578	562	.05

TABLE VI.—VICTORIA, 75-GALLON.

RATED CAPACITY, 75 GALLONS PER HOUR.

DATE.	Pounds of milk used.	Temperature of milk.	Revolutions of bowl per minute.	Pounds separated per hour.	Per cent. of fat in skimmed milk.
Feb. 13	773	85	6,650	790	.05
18	677	89	6,650	831	.05
19	739	90	6,650	812	.15
21	1,467	84	6,650	804	.05
23	1,556	85	6,650	769	.10
26	693	84	5,985	773	.05
27	1,070	90	7,315	732	.05
Mch. 2	413	86	6,783	779	.20
5	956	85	6,650	748	.05
9	1,047	86	6,650	825	.10
19	319	86	6,916	831	.10
Average	....	86	6,686	790	.09

It will be seen in general that the machines were run at very nearly their full capacity and that all of them were remarkably efficient as measured by the percentage of fat left in the skim milk. It will be noticed too, that in all the machines that were in use both in 1894 and 1895, uniformly better results were secured in '95 than in '94.

Some allowance should be made in comparing the results of these two years, due to the fact that in 1894 gravimetric determinations were made, and in 1895 the Babcock test was used, but making due allowance for this, there was considerably less fat in the skimmed milk in 1895 than in 1894 as shown by the following table:

PER CENT. OF FAT IN THE SKIMMED MILK.

	1894.	1895.
Butter Accumulator	.13	.10
DeLaval, Baby No. 3	.17	.06
United States, No. 3	.12	.05
Victoria	.19	.09

TESTS AT FACTORIES.

Our experience, and the experience of others, in the efficiency of cream separation has led us to believe that there is a considerable amount of variation in the work done by different separators of the same make, due to causes other than the skill of the operator, although this undoubtedly is usually the most important factor.

Hayward, in some tests made in factories in Pennsylvania,* found a very wide variation in the efficiency of separators, and tests reported from different experiment stations have also shown large variations in the efficiency of separators of the same make. An effort was, therefore, made to determine so far as possible what these variations are in actual creamery practice, both in regard to the machines themselves and the skill of the persons operating them.

Accordingly, during the summer, occasion has been taken to visit a considerable number of factories in the State located within convenient distances of Ithaca. In all, 22 factories and three private dairies have been visited and 30 machines of four different makes and nine different sizes and styles have been tested.

These tests were made on various dates between the middle of July and early in October, at a time when the flow of milk had largely shrunken and when the cows were harassed by flies and insects in bare pastures; an unfavorable season of the year for producing milk of easy separation. The results of these tests are shown in Tables VII to X, inclusive.

The different machines represented were the Alexandra Jumbo, DeLaval, Sharples and United States. No factories using the Danish Weston or Reid's Improved Danish were found in the territory visited, and it was not found possible in the limited time at our disposal to visit the localities in the State where these machines are used, but it is hoped that we may be able to do so at some future time.

In these tables we have included not only the average speed of bowl and average temperature of milk but the range of both, as it has been noticed that uniformity, particularly of speed, is an important factor in clean separation. In all the tests the machines were entirely in the hands of the factory operators and were run by them in their ordinary manner.

Equal portions of the skim milk were taken from the skim milk outlet at intervals of 10 or 15 minutes, according to the amount of milk separated, and from these mixed together a sample was drawn for analysis. The determinations of fat in the skim milk were made in skim milk Babcock bottles in all tests that were made previous to September 14th. In the tests made on and after that date the determinations were made with the new B. & W. double-necked bottle for testing skim milk and buttermilk. We have found this bottle much more convenient and more accurate for testing skim milk than the ordinary skim milk Babcock bottles, because of the ease with which it is possible to measure slight differences in percentages of fat. We have found, too, in comparison with the skim milk Babcock bottle, that the B. & W. bottle will give a slightly larger reading of fat. At each time a sample of milk was taken the temperature of the milk running into the bowl and the speed of the bowl were also taken. The capacity was found by timing the whole length of the run and reckoning the capacity per hour from the whole amount of milk separated in all cases where only one machine was used. In cases where there was more than one machine in the factory and both were fed from a common vat, the capacity was found by catching and weighing the skim milk and cream delivered for a certain definite time during the run.

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* Report of the Pennsylvania Agricultural Experiment Station, 1894, p. 33.

TABLE VII.—ALEXANDRA JUMBO.

RATED CAPACITY, 2,000 POUNDS PER HOUR.

DATE.	Number of factory.	Pounds of milk in whole run.	Average temperature.	Range of temperature.	Average speed of bowl, revolutions per minute.	Range of speed.	Pounds separated per hour.	Per cent. of fat in skimmed milk.
Aug. 19....	7	3,809	70	66–75	7,200	7,000–7,400	1,344	.25
20....	8	......	70	68–72	6,985	6,800–7,200	1,170	.15
20....	8	......	70	68–72	6,585	6,300–6,900	1,611	.20
21....	9	5,928	75	72–81	6,900	6,600–7,100	1,882	.20
23....	11	4,052	84	80–86	6,600	6,200–7,400	1,814	.33
Average .	....	......	74	......	6,854	....	1,564	.23

In Table VII are shown the tests of five different machines of the Alexandra Jumbo manufacture. The most remarkable thing in regard to them, it will be seen, is that most of them were run at a capacity quite a little below that rated by the manufacturer, in nearly every instance the operator taking rather thin cream.

TABLE VIII.—DELAVAL ALPHA NO. 1.

RATED CAPACITY, 2,500 POUNDS PER HOUR.

DATE.	Number of factory.	Pounds of milk in whole run.	Average temperature.	Range of temperature.	Average speed of bowl, revolutions per minute.	Range of speed.	Pounds separated per hour.	Per cent. of fat in skimmed milk.
July 17....	3	2,519	80	78–85	5,520	4,800–6,100	2,606	.08
Aug. 18....	6	3,629	74	73–76	5,806	5,700–6,000	2,592	.05
Sept. 16....	17	1,187	72	71–73	5,933	5,800–6,000	2,456	.08
20....	22	4,627	82	80–83	6,071	5,800–6,200	2,501	.04
21....	23	6,376	78	77–80	6,044	6,000–6,200	2,500	.03
Oct. 4....	24	5,588	82	78–85	5,844	5,600–6,000	2,747	.13
4....	25	1,802	86	85–90	6,280	6,000–6,400	2,040	.03
Average .	....	......	79	......	5,928	....	2,491	.06
BABY, RATED CAPACITY, NO. 2, 350; NO. 3, 600 POUNDS PER HOUR.								
					Rev.crn'k			
May 31....	1	205	96	......	54	....	362	.05
Sept. 14....	14	......	....	......	46	....	......	.06
18....	19	146	83	81–86	46	....	303	.16
Average .	....	......	90	......	49	....	333	.09
STANDARD, RATED CAPACITY, 1,100 POUNDS PER HOUR.								
					Rev.bowl.			
Sept. 19....	21	......	73	71–75	7,914	7,700–8,200	1,020	.25
19....	21	......	73	71–75	8,140	7,600–8,400	930	.15
19....	21	......	72	71–73	8,300	8,000–8,500	1,000	.16
Average .	....	......	73	......	8,118	....	983	.19

In Table VIII are seen the results of the tests of thirteen different machines of the DeLaval manufacture. The first seven machines were Alpha No. 1. Two of these, the machines in factories Nos. 3 and 25, were turbine machines; the others were belt power. All were of the late pattern, with rated capacity of 2,500 lbs., and it will be noticed that they uniformly gave good results up to the full capacity.

The next three machines were Baby Dairy size. In factory 14, No. 3; in the others, No. 2. It should be noticed in regard to the one in factory No. 19 that it was not quite evenly balanced and did not run steadily.

The last three machines were of the old standard hollow-bow type.

TABLE IX.—SHARPLES RUSSIAN.

RATED CAPACITY, STANDARD, 1,100 POUNDS; IMPERIAL, 2,000 POUNDS PER HOUR.

DATE.	Number of factory.	Pounds of milk in whole run.	Average temperature.	Range of temperature.	Average speed of bowl, revolutions per minute.	Range of speed.	Pounds separated per hour.	Per cent. of fat in skimmed milk.
July 16....	2	......	84	83–87	7,775	7,700–7,900	2,100	.40
July 16....	2	......	88	87–88	7,183	7,000–7,500	2,130	.65
Aug. 17....	5	1,718	80	78–82	7,800	7,700–7,900	1,874	.10
Aug. 24....	12	4,028	81	80–82	7,700	7,100–8,300	1,033	.05
Sept. 14....	13	2,509	85	84–86	7,433	6,800–7,600	1,158	.13
Sept. 17....	18	3,562	87	82–95	7,558	7,200–7,900	1,752	.45
Oct. 6....	18	2,716	90	87–91	7,675	7,400–7,900	1,873	.38
Average..	..	......	85	......	7,589	....	1,703	.31

In Table IX are shown the results obtained in five factories using either the Standard or Imperial Russian machines. It will be noticed, in factory No. 2 the operator crowded the capacity of both of his machines much above that rated by the manufacturer. This is, undoubtedly, the cause of the very large amount of fat in the skimmed milk from the machines in that factory. In factory No. 5 the capacity was also crowded; but, in this instance, the skim milk showed a very low percentage of fat.

In regard to factory No. 18, the only factory using the Imperial Russian machine, it was found in the first trial that the percentage of fat in the skim milk was quite large, and at the same time that the capacity was rather small. Upon the morning when the test was made the operator had considerable difficulty in maintaining a uniform pressure on his boiler, and the speed of the machine was quite variable. At the solicitation of the operator, a second visit was made to the factory and the machine tested again when the circumstances were more favorable, with the result that a somewhat lower percentage of fat was found in the skim milk.

TABLE X.—UNITED STATES.

RATED CAPACITY, 2,000 POUNDS PER HOUR.

DATE.	Number of factory.	Pounds of milk in whole run.	Average temperature.	Range of temperature.	Average speed of bowl, revolutions per minute.	Range of speed.	Pounds separated per hour.	Per cent. of fat in skimmed milk.
July 18....	4	......	83	82–84	7,120	7,000–7,200	2,220	.18
Aug. 22....	10	3,962	81	79–91	7,025	6,800–7,300	1,964	.25
Sept. 15....	15	1,870	94	90–98	7,600	7,200–8,000	1,403	.08
15....	16	3,850	88	80–100	6,075	5,600–6,600	1,650	.38
18....	20	2,902	78	77–80	6,586	6,400–6,800	2,176	.60
Average .	....	......	85	......	6,881	....	1,883	.30

In Table X are shown the tests of five machines of the United States manufacture; three of them — factories 4, 10 and 16, of the new style, or style "B" with the cups in the bowl, and two factories — 15 and 20, of the old hollow-bowl type. In regard to these, it should be noticed that in factory No. 16 the operator was very careless, both as to uniformity of speed and uniformity of temperature. The machine was set upon an ordinary floor and did not run steadily. It should be said, also, in regard to the machine in factory No. 20, that this, too, although sitting upon a stone foundation, ran quite unsteadily. A perceptible jar, to which the operator called attention, was noticeable throughout the whole run.

In regard to the tests as a whole, it will be seen that the percentages of fat are considerably higher than those found in the machines used at the Station; and it will be seen, also, that in most of the different kinds of machines there is quite a large variation between the highest and lowest percentage of fat — in every case amounting to 100 per cent., and in most cases to considerably more.

It will be further noticed that in the case of all of the various makes, except the Jumbo, at least one of the machines tested did what is called "practically clean skimming;" that is, the percentage of fat in the skim milk was one-tenth of one per cent. or less. In the case of the machines where a greater percentage was left in the skim milk, in many cases it was evidently due to carelessness of the operator; but, in other cases, it seemed to be some inherent quality of the machine. This was noticeably the case in factory No. 10

United States; factory No. 18, Sharples; and factories No. 7 and 11, Jumbo. It would seem, therefore, that since it is possible that machines of the various makes that will do perfect work can be made, that it is due the operator to demand from the manufacturer a guarantee of such perfect work.

RESULTS OF TESTS AT VARIOUS STATIONS.

As has been already noticed, several Experiment Stations have made similar tests of various separators.* In the table below we have grouped together the results of these tests, including both those made at the Stations and those made at outside factories. This table represents work done by five different Stations extending over a period of four years, and including some hundreds of different trials. It would seem that the average would indicate the efficiency of separation that it should be possible to attain with an ordinary amount of care and skill.

TABLE XI.

KIND, SIZE AND STYLE OF MACHINE.	Where tests were made.	Date.	Number of trials.	Temperature of milk.	Revolutions of bowl per minute.	Pounds separated per hour.	Per cent of fat in skimmed milk.
Accumulator............	Cornell......	1895	10	86	7,438	414	.10
Accumulator............	Cornell......	1894	9	..	7,200	416	.13
Average	....	....	..	..	......	......	.12
Alexandra Jumbo.......	Vermont.....	1895	3	..	6,480	1,625	.21
Alexandra Jumbo.......	Vermont.....	1894	4	83	6,925	1,820	.21
Alexandra Jumbo.......	Iowa	1894	32	84	7,458	......	.22
Alexandra Jumbo (at factories)...............	Cornell......	1895	5	74	6,854	1,564	.23
Average	....	....	..	..	......	......	.22

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* Vermont, Annual Report for 1892, p. 138. Annual Report for 1893, p. 94. Annual Report for 1894, p. 153. Bulletin 27.

Pennsylvania, Annual Report for 1892, p. 78. Annual Report for 1894, p. 23.

Wisconsin, Annual Report for 1891, p. 79.

Iowa, Bulletin 25.

TABLE XI — (*Continued*).

KIND, SIZE AND STYLE OF MACHINE.	Where tests were made.	Date.	Number of trials.	Temperature of milk.	Revolutions of bowl per minute.	Pounds separated per hour.	Per cent. of fat in skimmed milk.
Columbia No. 1	Cornell	1894	17	..	7,618	318	.13
Columbia No. 1	Vermont	1894	2	83	7,200	285	.05
Average	......	....	..	..	......	......	.09
Danish Weston	Iowa	1894	52	82	5,340	......	.07
Danish Weston	Vermont	1891	3	79	4,300	1,385	.10
Reid's Improved Danish	Cornell	1895	13	83	4,485	1,906	.11
Reid's Improved Danish	Vermont	1895	2	..	5,715	2,470	.07
Reid's Improved Danish	Vermont	1894	5	82	5,673	2,078	.17
Average	......	....	..	..	......	......	.10
De Laval Alpha No. 1	Cornell	1894	14	..	6,007	1,471	.10
De Laval Alpha No. 1	Iowa	1894	61	83	5.683	......	.06
De Laval Alpha No. 1	Pennsylvania	1894	5	85	6,200	1,851	.03
De Laval Alpha No. 1	Vermont	1895	6	..	5,670	2,506	.05
De Laval Alpha No. 1	Vermont	1894	4	85	5,780	1,800	.06
De Laval Alpha No. 1	Vermont	1892	13	84	6,100	1,867	.09
De Laval Alpha No. 1	Vermont	1891	4	80	5,900	1,976	.08
De Laval Alpha No. 1 (at factories)	Cornell	1895	7	79	5,928	2,491	.06
De Laval Alpha No. 1 (at factories)	Pennsylvania	1894	1	65	5,900	2,093	..3
De Laval, Alpha Acme	Cornell	1895	13	85	6,185	1,088	050
De Laval, Alpha Acme	Pennsylvania	1894	10	85	6,227	1,009	.08
De Laval, Alpha Acme	Vermont	1895	3	..	5,470	1,080	.10
De Laval, Alpha Acme	Vermont	1894	4	82	5,550	1,106	.09
De Laval, Alpha Acme	Vermont	1892	4	82	6,400	1,128	.09
De Laval, Alpha Acme	Vermont	1891	1	76	6,075	1,057	.08
De Laval, Baby No. 3	Cornell	1895	13	87	5,720	560	.06
De Laval, Baby No. 3	Cornell	1894	17	..	5,[illegible]98	571	.17
De Laval, Baby No. 3	Vermont	1894	1	..	6,000	585	.23
De Laval, Baby No. 3	Vermont	1892	7	84	6,700	486	.12
De Laval, Baby No. 2	Vermont	1894	1	83	......	282	.04
De Laval, Baby No 2	Vermont	1892	4	87	8,000	287	.07
De Laval, Baby No. 2	Cornell	1892	5		......	280	.09
De Laval, Baby No. 2	Pennsylvania	1892	25	91	crank. 46	......	.11
De Laval, Baby No. 2	Wisconsin	1891	35	85	42	......	.09
De Laval, Baby (at factories)	Cornell	1895	3	90	49	333	.09
De Laval, Standard (at factories)	Cornell	1895	3	73	bowl. 8,718	983	.19
De Laval, Standard (at factories)	Pennsylvania	1894	7	90	8,250	673	.29
Average	......	....	..	..	......	......	.13

TABLE XI —(*Continued.*)

KIND, SIZE AND STYLE OF MACHINE.	Where tests were made.	Date.	mber of trials.	Temperature of milk.	Revolutions of bowl per minute.	Pounds separated per hour.	Per cent. of fat in skimmed milk.
Sharples Standard Russian	Cornell	1894	20	..	7,150	1,112	.29
Sharples Standard Russian	Iowa	1894	54	83	7,461	......	.08
Sharples Standard Russian	Pennsylvania	1894	4	87	7,475	983	.13
Sharples Standard Russian	Vermont	1894	2	82	7,066	1,315	.17
Sharples Standard Russian	Vermont	1892	5	88	7,200	840	.20
Sharples Standard Russian	Vermont	1891	2	81	7,300	1,000	.23
Sharples Imperial Russian	Cornell	1894	5	..	7,460	1,900	.20
Sharples Standard Russian (at factories)	Cornell	1895	7	85	7,589	1,703	.31
Sharples Standard Russian (at factories)	Pennsylvania	1894	2	93	7,500	1,143	.30
Sharples Belt (at factories	Pennsylvania	1894	1	84	8,000	1,100	.60
Average	....	....	..	..	......	......	.27
United States No. 1, B.	Vermont	1895	4	..	7,230	2,142	.08
United States No. 1	Vermont	1894	3	82	7,022	1,911	.17
United States No. 1	Vermont	1891	2	85	6,950	1,867	.14
United States No. 3	Cornell	1895	19	87	7,578	562	.05
United States No. 3	Cornell	1894	10	..	8,389	658	.12
United States No. 3	Pennsylvania	1894	6	87	6,983	582	.09
United States No. 3	Vermont	1895	2		8,000	590	.07
United States No. 3	Vermont	1894	3	83	7,330	600	.08
United States No. 4	Pennsylvania	1892	6	88	8,260	386	.18
United States No. 5	Vermont	1892	6	87	8,300	308	.09
United States No. 1 (at factories)	Cornell	1895	5	85	6,881	1,883	.30
United States No. 1 (at factories)	Pennsylvania	1894	3	80	6,950	2,015	.22
Average	....	....	..	..	......	......	.18
Victoria, 75-Gallon	Cornell	1895	11	86	6,686	790	.09
Victoria, 75-Gallon	Cornell	1894	12	..	6,235	737	.19
Victoria, 30-Gallon	Vermont	1894	1	..	6,000	366	.38
Victoria, 30-Gallon	Pennsylvania	1892	11	88	crank 44	337	.19
Average	....	....	..	..	......	......	.21

The averages may be made up in two ways. In the above table we have averaged the series of tests at Stations with the single trials at factories, thus placing each machine tested on an equality and giving equal weight to each series of tests whether it was composed of few or many trials. In making the average in this way a single trial of one machine has as much value in determining the average as fifty trials of another machine although the latter probably indicates more accurately the true efficiency of the machine.

The other method is to average the individual tests having no regard to the number of machines used. In this case the influence of each machine upon determining the average is in proportion to the number of times it was used. If then a poor machine is tested many times and a good one but once or twice, or *vice versa*, the result may be misleading. In Table XII the average computed in both ways is given together with the maximum and minimum amounts of fat found in the skimmed milk in each group of machines in any single trial. This brings out more forcibly what has been said, that some machines of each style of manufacture do efficient work.

TABLE XII.

KIND OF MACHINE.	PER CENT. OF FAT IN SKIMMED MILK.			
	AVERAGE		Minimum.	Maximum.
	By series.	Of all trials.		
Accumulator	.12	.11	.01	.20
Alexandra Jumbo	.22	.22	.15	.33
Columbia	.09	.12	.05	.34
Danish Weston	.10	.08	.01	.25
DeLaval	.13	.09	.01	.50
Sharples	.27	.16	.05	.65
United States	.18	.12	.01	.60
Victoria	.21	.16	.05	.38

SUMMARY.

The results of all these trials show that it is possible to separate the cream from milk with a loss of not more than one-tenth of one per cent. of fat in the skimmed milk.

That in all probability there is nearly as much difference in efficiency of separation between different machines of the same make as there is between the different makes themselves.

HENRY H. WING.

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